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## FLUCTUATIONS IN THE ABUNDANCE OF THE VARIOUS YEAR-CLASSES OF FOOD FISHES

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# FLUCTUATIONS IN THE ABUNDANCE OF THE VARIOUS YEAR CLASSES OF FOOD FISHES

## I. Introductory Address

by

**Johan Hjort.**

During our session last year I was invited to deliver the introductory address and open the debate on this subject.

In the course of our preparations for the meetings this year, I was glad to find that the interest taken in the study of the fluctuations in the stock of a number of important species of fish is now so great, that notice has been received of no fewer than 19 papers to be read at the present meeting. I have therefore thought it superfluous, in an assembly which is devoting so much energy to the study of these questions, to attempt any historical and academic account of the progress of this important chapter of biological science. But it may, perhaps, be of some interest to open our meeting with a very brief survey of the purely general principles and ideas, underlying the investigation into these fluctuations in the stock of fishes, by which we must be guided if we are to attain results of practical utility.

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When we entered upon our international collaboration thirty years ago, the biological analysis of the organisms we caught in the sea was in the main confined to the systematic determination of the various species. In those days there was an enormous amount of work to be done in ascertaining the distribution and life-history of such large numbers of species. The spawning areas and the geographical occurrence of the different stages and ages of the species of fish were alike unknown; so the endeavour to gain fuller information regarding these primary conditions was very properly considered as the first task to be undertaken, and, indeed, as a task which was more than sufficient for the men and means then available. However, as the work advanced, the demand for a more refined biological analysis and morphological classification became urgent. It was realised that the terms of species were inadequate to give a clear and orderly grasp of the phenomena in the large field covered by the international co-operation, and that

recourse had to be taken to the conception of races or tribes as more natural and convenient morphological and biological units.

The biological meetings last year gave us an idea of the enormous amount of information that the study of the races belonging to the more important species of fish has added to our stock of knowledge. There is at present a somewhat sharp division of opinion between those, who regard the formation of races as the result of fortuitous hereditary combinations of characteristics, and those who regard it as due to an interplay of the power of adaptation shown by the animals concerned and the physico-chemical conditions predominating in particular areas of the sea. But in spite of these differences of opinion it is a matter of the greatest importance for all our researches and deliberations that the existence of these races and their geographical areas of distribution have been revealed.

The study of the fluctuations in the year-classes also calls for a more intensive analysis than can be based upon the definition of species. In order to be able to trace the vital events happening within the several races or tribes of fish belonging to different species, it is necessary to make further distinctions of at least two kinds:—

Firstly it is necessary to subdivide a given material of fish according to the age of the individuals. Happily this has proved possible by different means for many species of fish.

Secondly, due regard has to be given to the fact that the members of any race or tribe occur in nature arranged in several more and less distinct and stable groups, an arrangement which, as far as we can see, is based upon similarity in the biological and physiological state of the individuals.

It is of importance in this study of vital phenomena to conform as much as possible to the ideas and principles which have already been evolved in the study of human communities, and which are conveniently described by the term "vital statistics". But of course, it will be necessary to modify the methods to suit the different conditions.

It has been a constant source of astonishment and satisfaction to us, who have applied and been interested spectators of the application of this scientific procedure to marine animal life, that it really is possible to use the methods employed in studying terrestrial organisms, which can be observed in their natural element, when we are dealing with marine organisms. In other words, it is remarkable that we have actually been able to compile representative statistics by selecting comparatively small samples of the organisms of the sea, and then to prove that the distribution of ages in these samples was representative of the whole stock. But, of course, it is precisely in the selection of representative samples, even more than in the discovery and development of the methods of determining ages, that we see the true art of applying "vital statistics" to marine organisms.

The first desideratum in making an investigation of this kind is to obtain as clear a knowledge as possible of the area of distribution, the spawning places etc. of the tribe or group to be studied. Failing this, it may be preliminarily necessary as a makeshift to commence with a study of what may perhaps be termed the stock inhabiting a defined area.

Although this is a more indefinite base upon which to work, it may still lead to important results, and it will certainly in many cases be of considerable interest to study the stock of a particular species in a particular part of the sea, if that part forms a naturally self-contained area, even when the question of race is left out of account. It may, for instance, be useful to know the variations in year-classes among the shoals of herring in the North Sea. This knowledge may be of use to the fisheries. And an investigation of that kind resembles the ordinary statistics of the population of a human community, when no account is taken of any racial differences.

But supposing that the great fluctuation in the abundance of different year-classes is due to factors or conditions which affect the very earliest stages of individual fishes' lives, then clearly it is of special importance for our understanding of these fluctuations that we should distinguish, for instance, between the winter-spawning and the autumn-spawning sections of the herring population of the North Sea; in other words, we must in this case distinguish between two different stocks, composed of individuals of different races in the same area of the sea.

In addition to this extremely important limitation or definition of the stock to be studied, we have the no less important task of making a representative selection of individuals from the stock. It is obviously necessary, however, when dealing with marine organisms, even more than in the case of a stock of mammals on land, to distinguish between different groups of individuals in the stock, each of which must be analysed separately in order to discover how it is composed as regards age. We have called these groups biological groups in a population, because they are distinguished from one another by definite biological or physiological functions or activities. Thus it has everywhere been found that as soon as the individuals in a stock of fishes attain sexual maturity, their biology changes in a number of important respects. Merely from the point of view of collecting materials for representative statistics it is a particularly important point that the sexually mature individuals form shoals consisting exclusively of spawning fishes, among whom the age-distribution is so remarkably uniform that we find the most exact correspondence, as regards age percentages, in the composition of a large number of samples taken in the same year at distances of many nautical miles from each other. This is one of our most valuable points of departure in the general application of the idea upon which we are proceeding. And it is a fact that the study of the age-distribution of spawning shoals has led to most important results in the case of a long list of different species of fishes.

In dealing with the younger immature year-classes the work is much more difficult. Even in the case of species which have a number of these year-classes, we usually find that there are several biological groups whose composition as regards age is in itself ascertainable, but whose mutual numerical strength in relation to one another is extremely hard to decide. It would seem that the younger year-classes collect, in certain cases, in shoals where all the individuals are of about the same size and all are in search of the same kind of food. But, as the growth of every year-class is liable to considerable variations this grouping by size does not always correspond to a grouping by age.

Accordingly it has proved of great value that we have been able, in certain cases,

to obtain a quantitative idea of the numerical strength of the newest and youngest year-class, known as the "0"-class, owing to the fact that it often lives separate from the older year-classes. By systematic trawling in the areas where the "0"-group is found, it has been possible to compare corresponding trawl catches from one year to another, and the picture obtained by these comparisons has actually been reflected in the subsequent composition, from the point of view of age, of the spawning shoals.

The study of the varying age-distribution in stocks of the chief species of fish has in many ways thrown new light on old and new fishery problems. Not only has it been possible, in many cases, to explain the mysterious fluctuations in the yield obtained by the fishing industry from year to year — a phenomenon which has always puzzled people. It has even been possible to forecast future fluctuations, an achievement of very considerable practical value. Already there are several countries which make use of these forecasts; independent observations are made by the industry, based upon the fluctuating size of the fish, which corresponds in the main to the age-distribution. Old delusions have consequently been thrown overboard; and here again science has won its greatest triumph, in that discoveries it has made in the field of practical life have come to be looked upon as time-honoured commonplaces.

But the work must not be allowed to relapse into inexact methods if the fishing industry is to profit fully by the knowledge gained. A biological service must be organized for the regular observation of the age-distribution in the stock, and of the relative — and even in time of the absolute — numerical strength of the year-classes. It will be something like the meteorological service which records the weather and weather prospects. In the organization of this biological observation and control of the livestock of the ocean the International Council will have a task which in itself will repay all the work and expense that its existence during the past thirty years has occasioned.

Now an organization of the kind I have sketched will gradually be able to extend its activities to new seas and new populations, and as it does so, the value of the material thus collected will increase. By mutual comparison of the biological conditions in different seas it will become possible to understand what wealth these seas offer in relation to each other, the conditions of life they afford for the various species of fishes, and, following from all this, the possibilities and limits of development open to the fishing industry. Little by little this should also make it easier to press on to the discovery of the causes behind the fluctuations.

At present we approach these tasks in a spirit of uncertainty and enquiry. We have learnt that there must be quite definite circumstances which account for the superabundance of certain year-classes. For there is no agreement between the various species of fish in this respect in the same year. Only in particular cases (herring in the coastal waters of Norway and the sea round Newfoundland, and cod in the coastal waters of Norway and Davis Strait) has it been observed that the same year-classes were unusually abundant, on both occasions in waters situated widely apart.

By setting up an international organisation for this biological service new light will be thrown upon a number of questions. It will be possible to compare the growth of the various year-classes in different years and waters, and this information will in

turn explain the sea's production of animal life and demonstrate the possibilities of the fishing industry on a far more reliable basis than hitherto. In order, however, to secure a really satisfactory knowledge of these possibilities our biological statistical work must proceed conjointly with a biochemical study of the fluctuating conditions in the sea, upon which depend not only the numbers of individuals in the year-classes, but the growth of these individuals as well.

For all these studies an international biological organisation will act as the hub, connecting, on the one hand, with the fisheries and lending them its aid, while, on the other hand, theoretical biology, centering round it, will receive its support in exploring further the more general problems of science.

# II. The Renewal of a Fish Population studied by Means of Measurement of Commercial Catches.

## Example: the Arcto-Norwegian Cod Stock.

By

**Oscar Sund,**

Norw. Directorate of Fisheries, Bergen.

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The ideal means of studying the fluctuations in a fish population is no doubt age determination. Unfortunately it is attended by two great difficulties. In order to give an adequate representation of the stock of fishes considered it entails a great amount of work and expense, and worse still, in many species of fish it is utterly unreliable except for the earlier year classes. This is precisely the case with the particular stock of cod which we have designated as the Arcto-Norwegian according to the unquestionable results as to distinction from other stocks and definition of habitat gained by the marking experiments in 1913 and 1914 which were initiated through the energies of Prof. HJORT, the then Director of Fisheries.

There is, however, another method by means of which it is possible to detect and follow the influx of fresh recruits to a fish population and which can be based on a broad foundation of observations without undue cost in collection or labour in analysis, giving results of an objective character even if lacking somewhat in precision. This is the method of extensive measurements of commercial catches which may be applied in all cases where an appreciable correlation exists between the size and the age of the fish for a period of life corresponding to the number of years during which a year class is able to supply a relatively important percentage of the catch.

In the case of the cod this means a series of about 9 years (age 4 to 13), in the case of the herring about 15 years (age 1 to 15) and in the case of the sprat at most only 3 (age 1 to 3). Speaking only about these three species it is evident that the method is of use only in the case of the cod. In this fish growth goes on at an appreciable rate up to an advanced age while in the herring it is mainly completed many years before its commercially important life has come to a conclusion. In the sprat the number of year groups of interest to the industry is so restricted that a knowledge of the dominant year classes can only have a short-lived value. On the other hand these two clupeids afford in their scale rings a most satisfactory means of establishing the strength of year classes.

Not so in the case of the cod. Here the information obtained from scales or otholiths is apt to be seriously blurred by personal bias as soon as the age of the fish is, say,

6 years or more. But as the cod is the one of the two species which form the mainstay of the Norwegian fisheries, it is felt as urgently important to gain every year as good a knowledge of the fluctuations in the stock as it is possible to obtain. The institution of systematic research into this matter is due to the activities of Dr. Hjort who directed the Norwegian fishery investigations in their modern phase up to a few years ago. The general results as to the fluctuations of the stock of cod may be gathered from his paper: The Fluctuations of the Great Fisheries, based upon observations up to 1914.

In order to utilize the results gained and to maintain a continual observation of the stock it proved necessary to increase the number of fish considered far beyond the possibilities of individual age determination because of the great diversities met with in the size of the fish during any season.

In dealing with the resulting mass of figures the need was urgently felt of a method comparable to that introduced by the late Dr. C. G. Joh. Petersen in dealing with measurements of young fish which had proved entirely successful in this case. A measurement series of older fish of different ages, however, tends more or less, when graphically represented, to show a massive form, often tending towards a binomial distribution as if it contained only one year class. As all such curves show this character, recourse must be had to the old and simple principle: if you want to know the essential and characteristic features of a phenomenon, remove everything which is common to all phenomena of the same class. This principle is old in meteorology where the data as a matter of course are considered as differences from means formed by prolonged observation.

In the case under consideration regular yearly measurements were begun in 1913 when about 7,000 cod were measured and have been continued since on a steadily increasing scale, the number measured during the last ten years varying between 50 and 100,000 cod landed in the three principal fishing areas, Finnmark, Lofoten and Möre. At Lofoten and Möre the fishing is done in the first four months of the year and exclusively adult fish on their spawning migration are caught while both young and old, recovering, fish are caught at Finnmark, mainly in the early summer months, from April to June.

In order, now, to obtain the mean distributions of size, characterising the different months of the season or the different areas each year and finally all years available, a system of weighting the measurement series had to be devised. By weighting is in this connection to be understood the operation of giving to each series the numerical importance corresponding to the assumed number of individuals of which each measurement series is supposed to be representative. The plan followed has been to add monthly all original series within a limited area. These month-area series are then weighted according to the months catch in the area and give when totalled the years curve of sizes, shown in Fig. 1 as nr. per 10000. It would have been preferable to weight the monthly series by means of the mean catch per fishing unit but this has been found impracticable in this case. The yearly series, however, are so weighted (Fig. 2) and their total (Fig. 3) is therefore considered to represent the average size distribution in the different areas as correctly as it has been possible on the data available.

The unit of fishing used has been a fisherman's day's work irrespective of gear. And the number of fish caught pr. fishing unit is the best or only expression we can get

of the number of fish in the sea at the place and time. It is believed that the use of different gear (mainly long lines and gill nets), does not influence the size of the unit appreciably as the percentages of fishermen using the two kinds of gear vary within narrow limits as do the percentages of the different boat classes. If a fishery is done by trawl, the natural unit will be the trawl hour, but such a "self-made" unit was unfortunately not available in our case.

It was first tried to utilize the average distribution curve by subtracting it from the particular curve to be considered and the results achieved were certainly encouraging. Still clearer pictures were, however, obtained by expressing all the ordinates of a particular

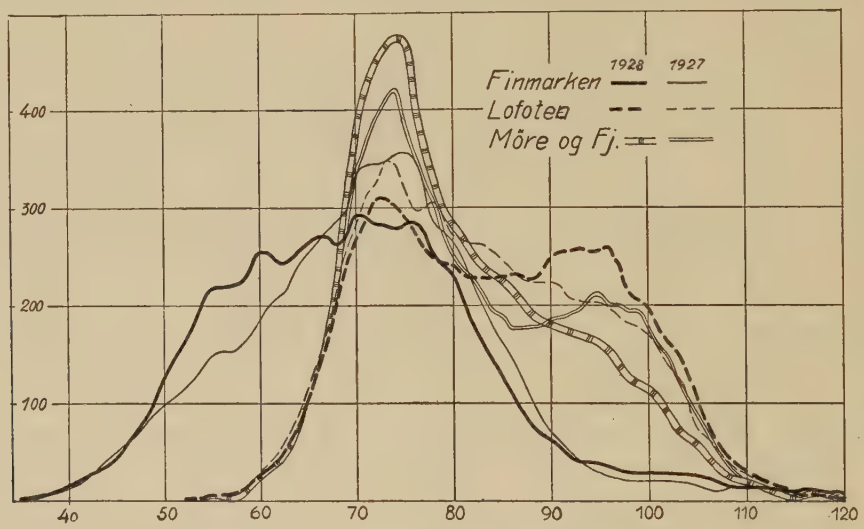


Fig. 1. Size distribution in 1927 and 1928 of cod in the three principal codfishing areas of Norway. Ordinates are the nr. of fish per ten thousand in each centimeter class. The curves are smoothed according to the formula $(a + 2b + c)$. Total nr. of cod measured in 1927: 73866, in 1928: 76017.

curve as percentages of the average curve or series. These average curves for the different districts are shown in Fig. 3. As all calculation can be done on the slide rule, the amount of work involved is by no means deterrent although the number of entries in a cod measurement curve approximates one hundred, the measurements being made to the nearest centimetre and smoothed by the usual method before any weighting is done.

We shall now look at the main results achieved by this method (Fig. 4). First of all it is evident that you can recognise a number of moving curve tops (and minima). Then another fact is apparant, one can see how fluctuating the catch has been in the different districts in the same years.

In 1923 e. g. there is a great increase in the number of big spawning fish both in the north (Lofoten) and especially in the south, which could not be presumed from the immediately foregoing years.

In order to be able to survey the measurements of each class of fish, the spawning

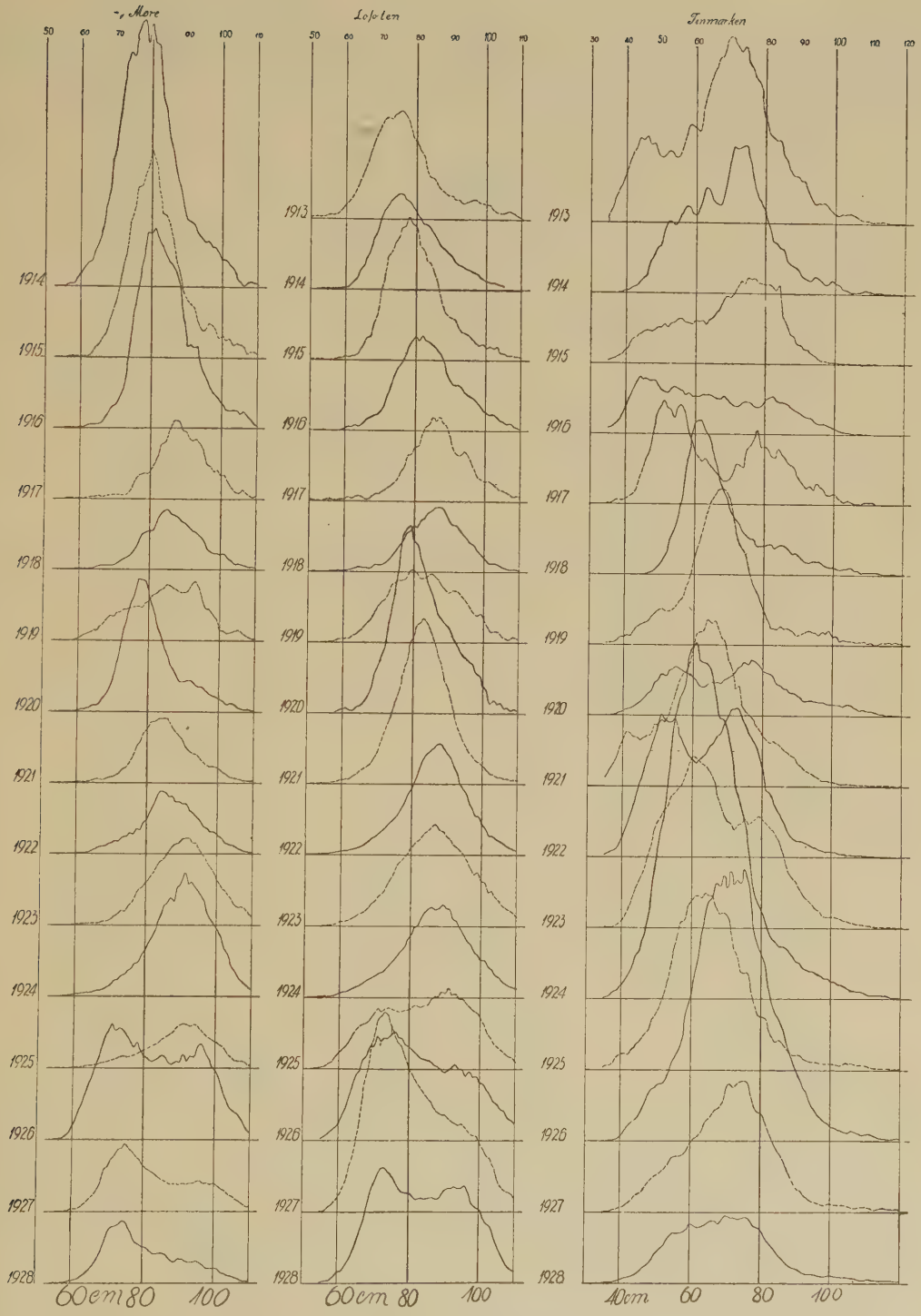


Fig. 2. Size distribution of cod 1913—1928, in the three principal districts. The ordinates are so calculated that the area of each curve corresponds to the relative catch per man per day. (One square equals 10 fish per man per day.)

and the summer fish, without reference to this difference between the northerly and the southerly spawning areas, the respective year curves have been combined after having been weighted according to the respective yearly catches and the resulting curves covering also the year 1928 are shown in Fig. 5.

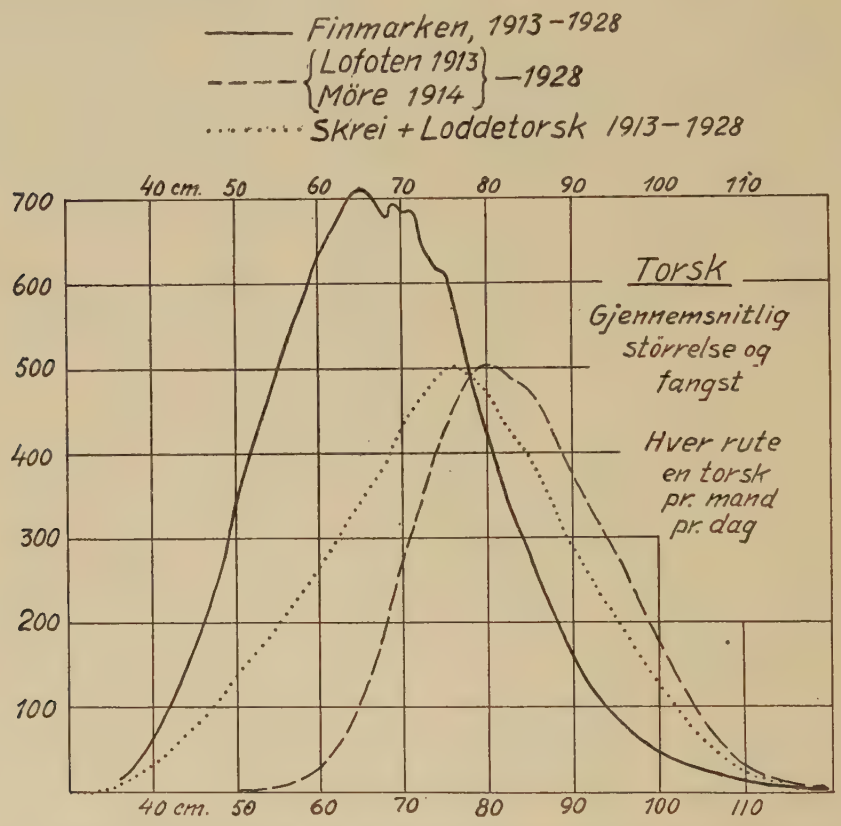


Fig. 3. Average size distribution and catch per man per day for the period 1913—1928. Ordinate figures refer to nr. of fish in each cm.-class per 1000 men per day.

——— Finmark cod ("Loddetorsk").
— — — — Lofoten combined with Møre ("Skrei" or spawning cod).
. . . . . Finmark and spawning cod combined.

By means of these curves we are able to give the following description of the recruitment of the stock: in Finnmark there appeared in 1913 a great many small fish, of the 1909-brood and a good surplus of larger fish, largely of the 1904-brood as known from earlier measurements not shown here. The 1909-brood did not have any further effect on the catch either as summer fish or as spawners. If the latter had been the case we should have had a surplus of small spawners in 1915 but as one sees, this was not the case. The larger Finnmark fish, however, mainly of the 1904 brood made up the bulk of the catch of spawners up to 1918 when, however, the stock had been brought down to a mere remnant owing to no really good brood year having occurred for a number of years.

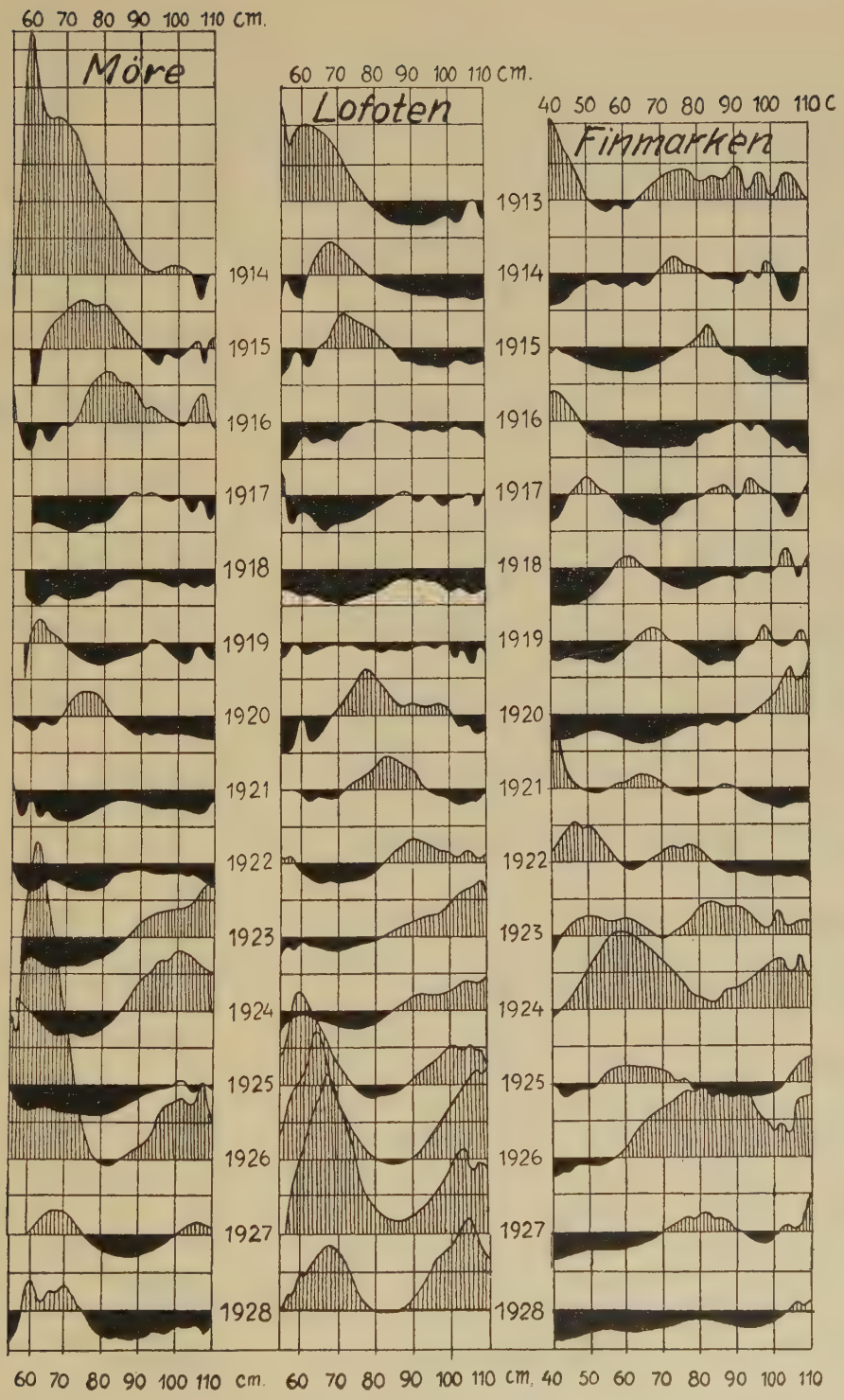


Fig. 4. Excess (shaded) and deficit (black) of nr. of cod caught per man per day in percentages for each centimeter group of the averages calculated for the period 1913—1925, separately for each of the three districts. The distance between horizontal lines represents 100 per cent.

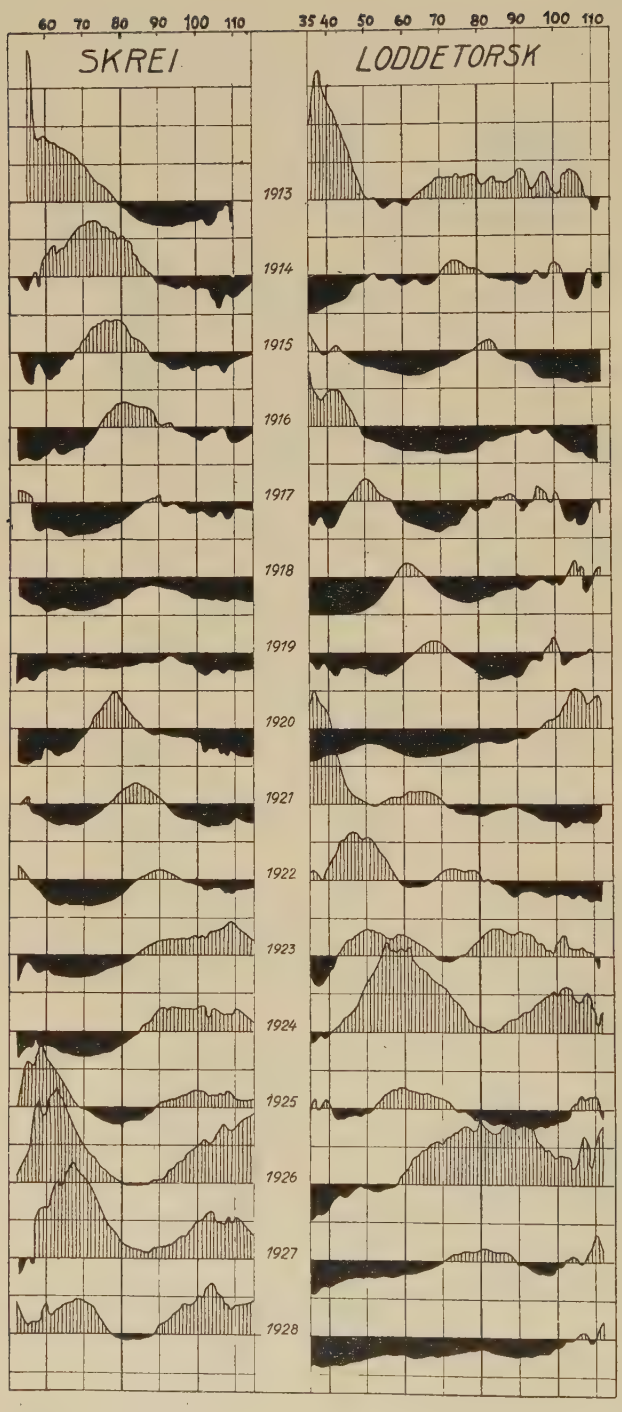


Fig. 5. Excess (shaded) and deficit (black) of spawning cod and for Finmark cod for each cm-group per man per day as percentages of averages calculated for the period 1913—1928 (as shown in fig. 3).

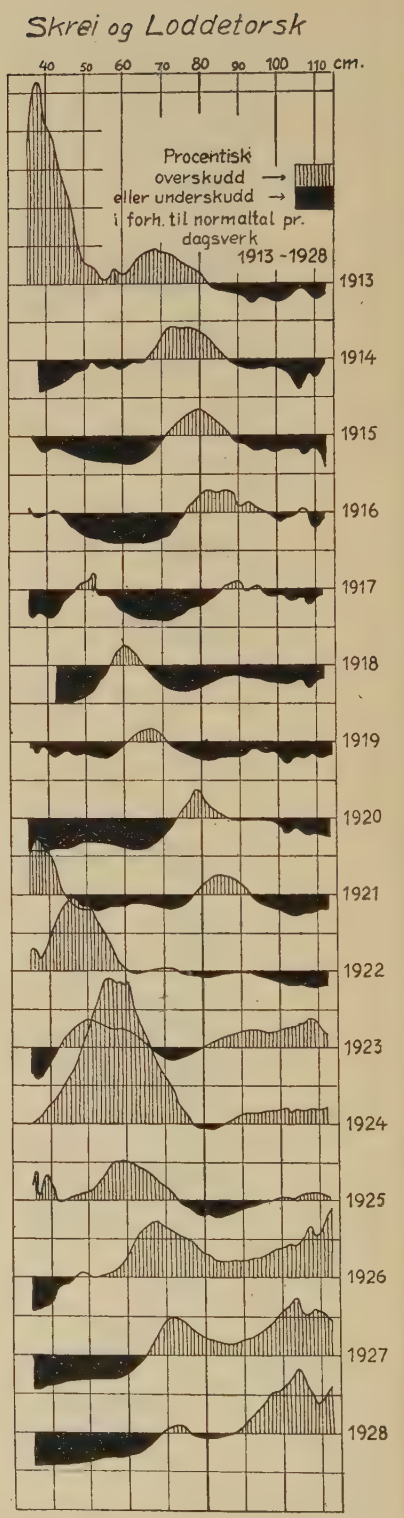


Fig. 6. Excess and deficit of total norwegian catch of cod as percentages of average calculated for the period 1913—1928 (as shown in fig. 3).

The first sign of an efficient recruitment appears in the 1916 Finnmark curve as a surplus of small fish, evidently of the 1912-brood which was confirmed by scale reading. This curve top can be seen moving along the size-scale year by year up to 1919 and when it disappears from the Finnmark record. In 1920 it is found again as a distinctive surplus of middle-sized spawners and recurs each year afterwards blending as time goes on with two younger year classes the origin of which is seen from the Finnmark or Loddetorsk series. They are evidently the 1915 and 1917 broods.

The latter, however, soon gets mixed up with a new brood, the 1919, appearing in Finnmark in 1923 as 4 years old and as spawning fish as early as 1925. The 1919 brood has been the main object of the skrei fishing ever since, although the 1915 and 1917 broods have come to the spawning grounds in later years in much greater numbers than could be anticipated. This may probably be interpreted thus that a certain proportion of the fish have been hiding in the vast areas of the Barents Sea not used by our fishermen or on the outer edge of the continental shelf along our coasts. That sometimes a large proportion of the stock abstains from spawning is a formal possibility, but it would, I believe, be too rash to call it anything more than that on the present evidence.

In a last picture (Fig. 6) we have combined in the same manner as described before, the measurements of all cod measured in Norway. Here the whole material is, so to say, represented in a nutshell. The different "trends" or broods can here be followed in one diagram.

Of particular interest is to be noted the absence of any surplus of small fish in any of the years since 1925, indicating the probability of no recruitment which can be available as spawning fish before the year 1932. Although the 1919 brood has proved so rich that it has been supporting rich fisheries during all the years 1924 to 1929 (failures in certain districts not considered), there is reason to fear that the stock of spawning fish must decline seriously 2 or 3 years hence, even if a rich brood should appear this summer among the summer fish.

The method of treating measurements here described is not claimed as a self sufficient method of gaining quantitative information as to the renewal of the stock, but only as means to enable the measurements to be compared and combined with other observations.

# III. On Fluctuations in the Abundance of Cod.

By

**D'Arcy W. Thompson.**

Since the year 1901 the Fishery Board for Scotland has kept detailed statistics at the Port of Aberdeen, shewing not only the quantities of fish landed but also the place

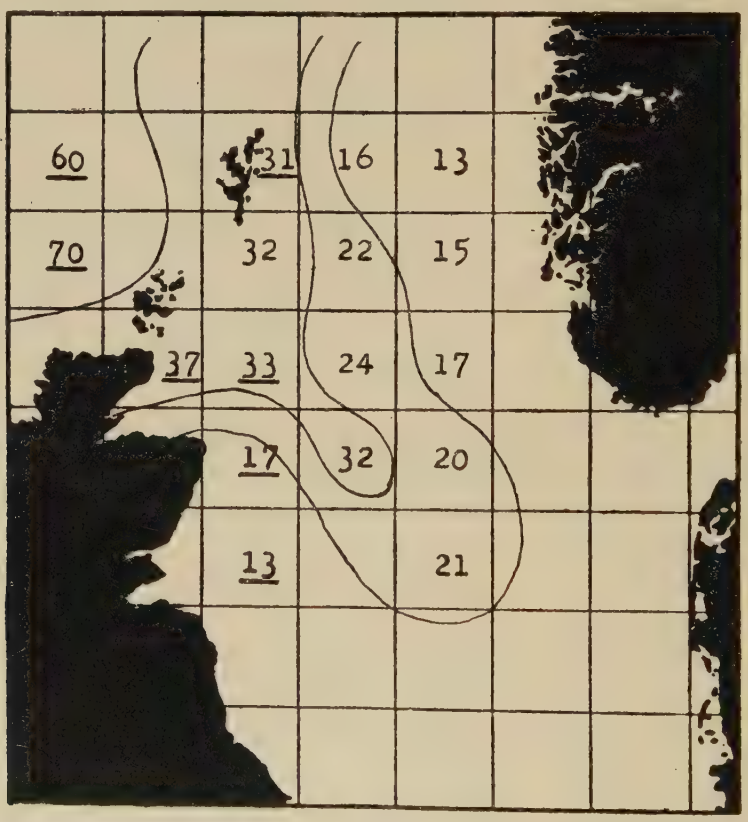


Fig. 1. Average Catch of Cod, in cwts., per 100 hours' fishing. Mean of 1901—1914, plain figures; mean of 1901—1927, underlined.

of capture according to certain now well-known areas, and the time spent on fishing. In a certain number of the more important areas it is now possible to shew the average

quantity caught, per hundred hours' fishing, of each species of fish, month by month, (with scarcely a break), for the long period of twenty-eight years.

We may use such information in various ways. Suppose, for example, we are considering the table (Table I) which shews the quantity of Cod caught, per hundred hours, month by month, from 1901 to 1927, in the Shetland area (Area X).

1) The first and simplest thing we can derive from it, is a good average value of the annual catch of Cod in this area, year in year out. In the Shetland area it happens

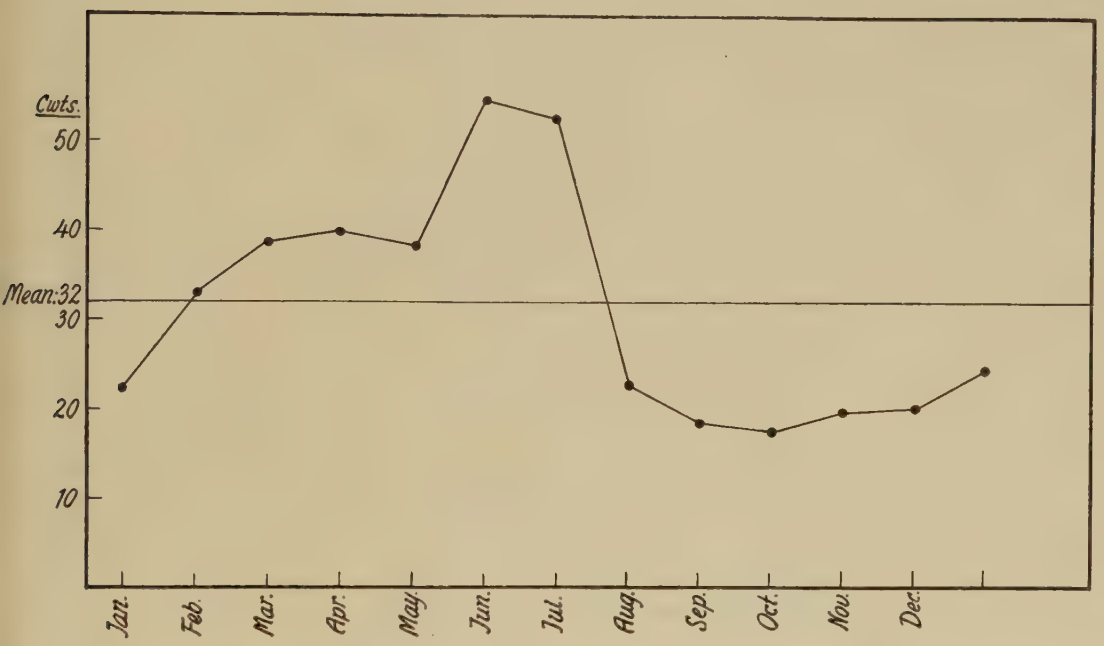


Fig. 2. Area X. Shetland. Mean Monthly Catch of Cod, by Aberdeen Trawlers, per 100 hours' fishing; 1901—1927.

to be about 30 cwts. per 100 hours' fishing. Such values, plotted on the chart for a number of areas, will form a chapter in the natural history of the cod, shewing its general average distribution (Fig. 1); and these numbers for the several areas, each of which has been arrived at independently of the rest, will always be found to form a more or less orderly arrangement, shewing gradual increase or decrease of the density of distribution in particular directions. Such an orderly arrangement is neither more nor less than an illustration of the "principle of continuity", without which all our investigations would be made in vain.

2) The series is long enough to give us good averages, not only for the whole period (as we have already said), but for each several month. We have, in short, the basis of a set of charts to shew the quantitative distribution of the cod (or other fish) in January, again in February, etc.; and thereby to throw some light on the migrations of the species.

3) The average quantities caught per 100 hours in the consecutive months (Table II),

Table I. Area X. Shetland. Average Catch of Cod by Aberdeen Trawlers, per 100 hours' Fishing, in cwts.

| | Jan. | Feb. | March | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1901 ..... | .. | .. | .. | 27 | 11 | .. | 39 | .. | .. | .. | 4 | 2 | 17 |
| 1902 ..... | 14 | 18 | 7 | 61 | .. | .. | .. | .. | 10 | 10 | 15 | 7 | 18 |
| 1903 ..... | 9 | 43 | 12 | 22 | 22 | .. | .. | 19 | 31 | 33 | 27 | 64 | 28 |
| 1904 ..... | 21 | 46 | 64 | 72 | 34 | 104 | 74 | 4 | 24 | 25 | 16 | 12 | 41 |
| 1905 ..... | 40 | 16 | 24 | 21 | 72 | 63 | 104 | 34 | 29 | 24 | 25 | 37 | 41 |
| 1906 ..... | 52 | 47 | 33 | 20 | 47 | 66 | 65 | 27 | 30 | 23 | 27 | 20 | 38 |
| 1907 ..... | 18 | 23 | 71 | 38 | 30 | 38 | 43 | 25 | 28 | 19 | 13 | 12 | 30 |
| 1908 ..... | 20 | 13 | 64 | 49 | 36 | 30 | 26 | 27 | 22 | 16 | 21 | 15 | 28 |
| 1909 ..... | 41 | 38 | 23 | 45 | 45 | 52 | 46 | 12 | 13 | 21 | 27 | 7 | 32 |
| 1910 ..... | 20 | 33 | 60 | 54 | 24 | 70 | 81 | 9 | 16 | 20 | 21 | 61 | 39 |
| 1911 ..... | 13 | 27 | 38 | 45 | 57 | 156 | 91 | 27 | 11 | 18 | 25 | 27 | 44 |
| 1912 ..... | 24 | 31 | 92 | 70 | 78 | 102 | 52 | 30 | 16 | 16 | 35 | 21 | 47 |
| 1913 ..... | 55 | 48 | 36 | 49 | 55 | 116 | 130 | 56 | 20 | 16 | 15 | 20 | 51 |
| 1914 ..... | 16 | 24 | 42 | 24 | 39 | 65 | 45 | 16 | 10 | 18 | 19 | 15 | 28 |
| 1915 ..... | 14 | 17 | 42 | .. | 58 | 42 | .. | .. | 12 | 15 | 14 | 4 | 24 |
| 1916 ..... | 33 | .. | .. | .. | 21 | .. | .. | 10 | 12 | 12 | 11 | .. | 17 |
| 1917 ..... | 15 | 56 | 13 | 28 | 48 | 34 | 28 | 14 | 4 | 13 | 8 | 7 | 22 |
| 1918 ..... | 21 | 19 | 27 | 42 | 26 | 37 | 29 | 14 | 9 | 14 | 19 | 26 | 24 |
| 1919 ..... | 11 | 84 | 28 | 37 | 111 | 52 | 61 | 51 | 47 | .. | 29 | 38 | 50 |
| 1920 ..... | 43 | 56 | 36 | 81 | 34 | 52 | 31 | 26 | 16 | 15 | 20 | 12 | 35 |
| 1921 ..... | 34 | 50 | 51 | 51 | 64 | 62 | 66 | 17 | 23 | 9 | 20 | 18 | 39 |
| 1922 ..... | 30 | 49 | 35 | 32 | 26 | 33 | 43 | 29 | 25 | 30 | 35 | 16 | 32 |
| 1923 ..... | 9 | 21 | 22 | .. | 5 | 6 | 67 | 5 | 7 | 10 | 20 | 3 | 15 |
| 1924 ..... | 6 | 7 | 36 | 28 | 9 | 23 | 23 | 9 | 6 | 11 | 11 | 16 | 15 |
| 1925 ..... | 16 | 12 | 44 | 27 | 12 | 11 | 8 | 26 | 10 | 6 | 11 | 6 | 16 |
| 1926 ..... | 46 | 24 | 35 | 15 | 13 | 17 | 12 | 14 | 16 | 17 | 25 | 26 | 22 |
| 1927 ..... | 9 | 66 | 30 | 22 | 15 | 24 | 53 | 38 | 35 | 24 | 25 | 28 | 31 |
| Mean ..... | 24.2 | 34.7 | 38.6 | 40.0 | 38.1 | 54.5 | 52.5 | 22.4 | 18.5 | 17.5 | 19.9 | 20.0 | 30.5 |
| Mean smoothed | 26.3 | 33.5 | 37.8 | 39.5 | 44.7 | 49.0 | 43.3 | 31.3 | 19.5 | 18.6 | 19.1 | 21.4 | .. |

constitute a curve of seasonal distribution, generally a very smooth curve, and usually (but not always) with a single annual maximum and minimum (Fig. 2). These maximal and minimal dates, or epochs, can be roughly determined by inspection of the curve; or more accurately by simple harmonic analysis. On Area X (Shetland) cod are seen to reach their maximal abundance in the month of June, and a minimum in October. In the Pentland Firth region (XVII) we have a double maximum, in March and in July, the principal minimum being in October. Off Aberdeen (XXIII) the same double maximum is slightly indicated; but further south (XXIX) there is one clear maximum about the month of March (Fig. 3). These and the corresponding dates, or epochs, for other areas may again be plotted on a chart; and will again be found to group themselves in an orderly and significant fashion.

4) The average catch for all twelve months together (or as many as happen to be represented in the available statistics) may now be used to give an average annual catch for the successive years of the whole period, thus giving a view, or epitome, of

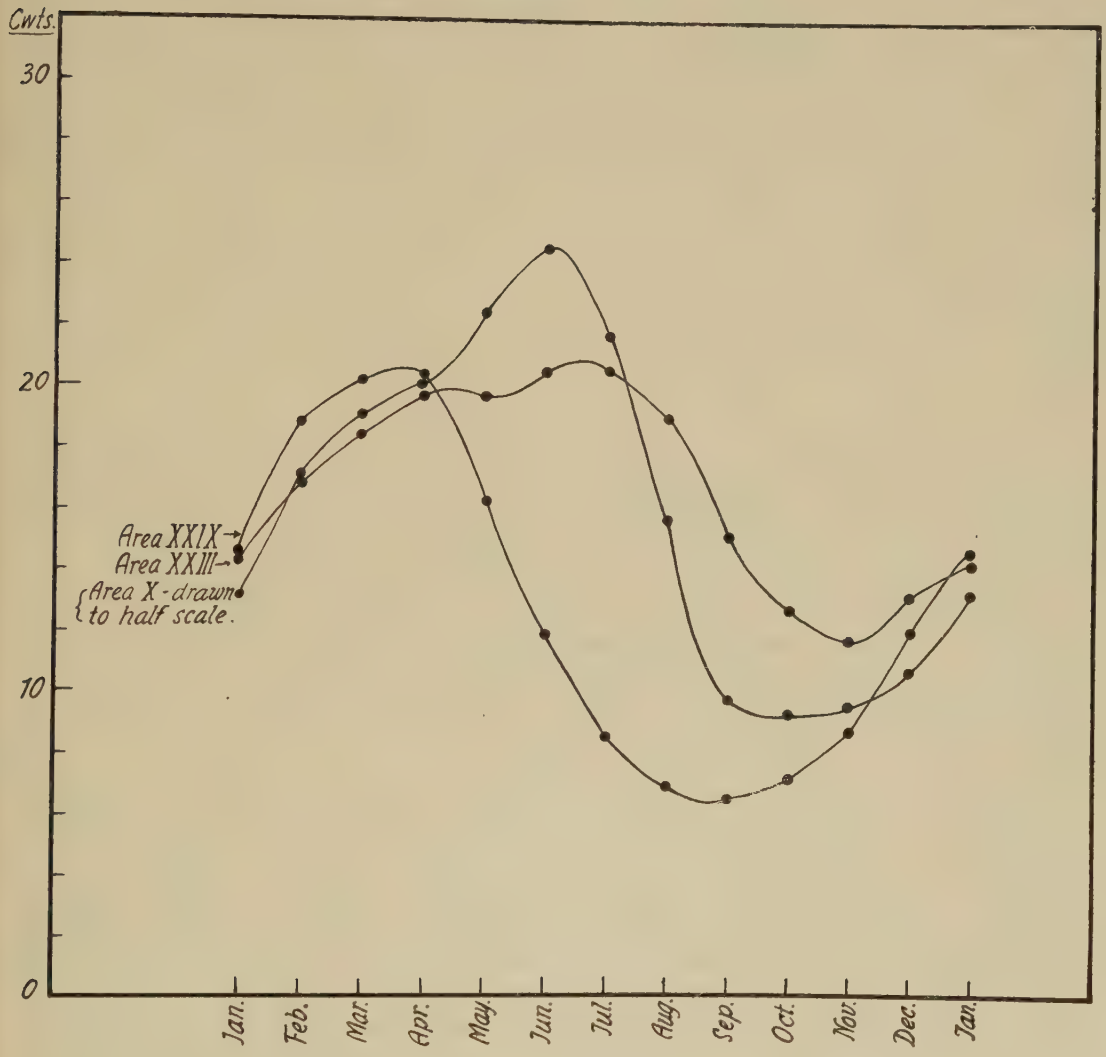


Fig. 3. Mean Monthly Catch of Cod on certain areas: 1901—1927. (Smoothed curves).

the actual fluctuations in abundance, on this particular area, of this particular fish (Table III). In the case of cod on area X (Shetland), we discover in this manner that there have been three well-marked waves of abundance during the period in question (Fig. 4); maxima occurring in or about the years 1905, 1912 and 1920, while the approach of a fourth maximum (probably due about 1928—29) is indicated on the curve. The corresponding minima are shewn in the years 1908, 1916—17, and 1924. The period of fluctuation appears, therefore, to be in this case approximately eight years.

Table II. Mean Monthly Catch of Cod, in cwts., per 100 hours' fishing, by Aberdeen Trawlers: 1901—1927. (Nearest whole numbers: unsmoothed).

| Area | X | XVII | XVIII | XXIII | XXIX |
|---|---|---|---|---|---|
| January | 24 | 55 | 24 | 15 | 17 |
| February | 35 | 51 | 24 | 15 | 16 |
| March | 39 | 79 | 37 | 21 | 23 |
| April | 40 | 54 | 46 | 19 | 22 |
| May | 38 | 31 | 33 | 19 | 16 |
| June | 55 | 45 | 30 | 20 | 11 |
| July | 53 | 53 | 35 | 22 | 9 |
| August | 22 | 22 | 37 | 19 | 6 |
| September | 19 | 15 | 35 | 16 | 6 |
| October | 18 | 10 | 31 | 10 | 8 |
| November | 20 | 17 | 30 | 13 | 8 |
| December | 20 | 23 | 26 | 13 | 10 |

5) The fluctuations may, with no small advantage, be followed out not only from year to year, but in detail, from month to month, through the entire period, as has been done in some of our former publications. And here again an orderly and regular fluctuation is revealed, especially after a certain amount of legitimate "smoothing".

These statistics may be used in various ways, not only to supplement but to check one another. For instance, we shall find that if, instead of the annual means from year, we take the twenty-seven consecutive Mays, or Novembers, etc., the single months will usually be sufficient to shew, very fairly well, the same periodic fluctuations which we discovered from the mean landings of successive years.

It is very important to discover how far identical or similar fluctuations are indicated in neighbouring, or even in more distant, areas. We shew, accordingly, corresponding curves for the average annual catch of cod in Areas XXIII (off the Aberdeen Coast), and in area XXIX immediately to the southward thereof (Fig. 5). These two curves, derived from perfectly independent data, are markedly similar to one another, and also to that which we have already studied for the Shetland area (X). The same three fluctuations are shewn, and the fourth or most recent one is shewn better than before. Not only so, but as we may see from Table III, the very same fluctuations are apparent in the case of the Pentland Firth area (XVII), and in area XVIII to the southward thereof and north of XXIII.

It is obviously of great interest, after discovering that the fluctuations are similar on adjacent areas, to determine whether the curves be alike in phase: that is to say, whether the epochs of maximum and minimum are identical, or whether the several areas shew a definite order of succession. This, however, is a matter not to be dealt with except after very careful study and scrutiny.

In the case of Cod, and in the areas here illustrated, it may be confidently said that there is no evidence of diminution of the average catch in the long run, or of so-

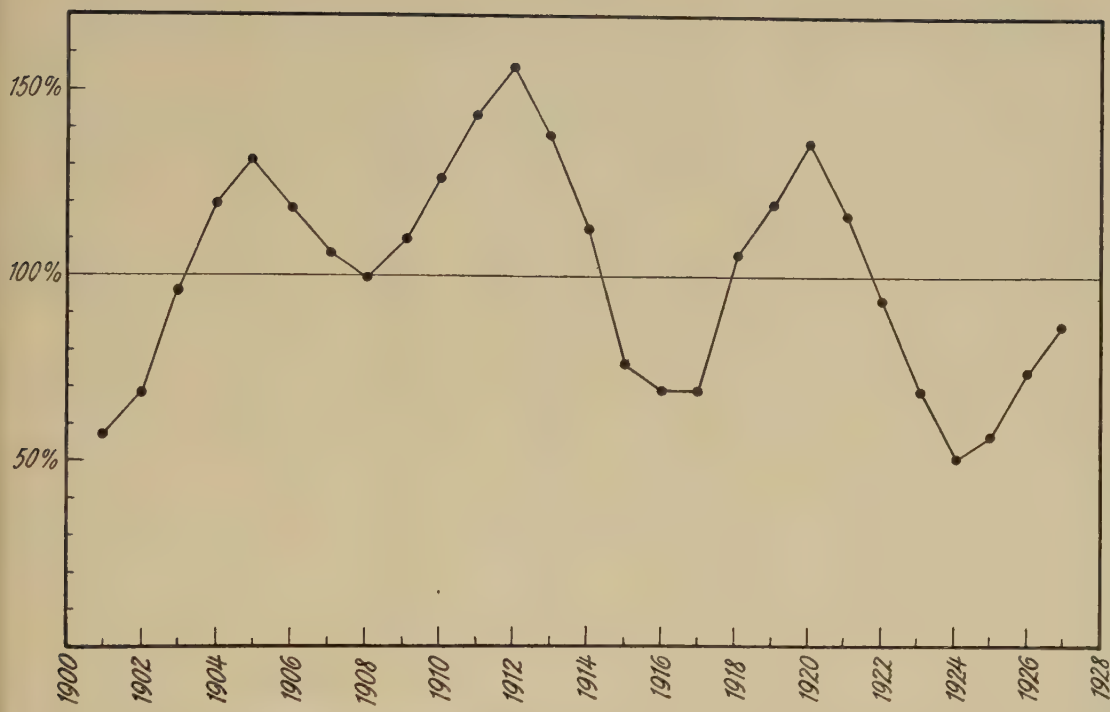


Fig. 4. Area X. Shetland. Mean Annual Catch of Cod per 100 hours' fishing, by Aberdeen Trawlers; reduced to percentages of the Mean for the whole period. (Smoothed curve).

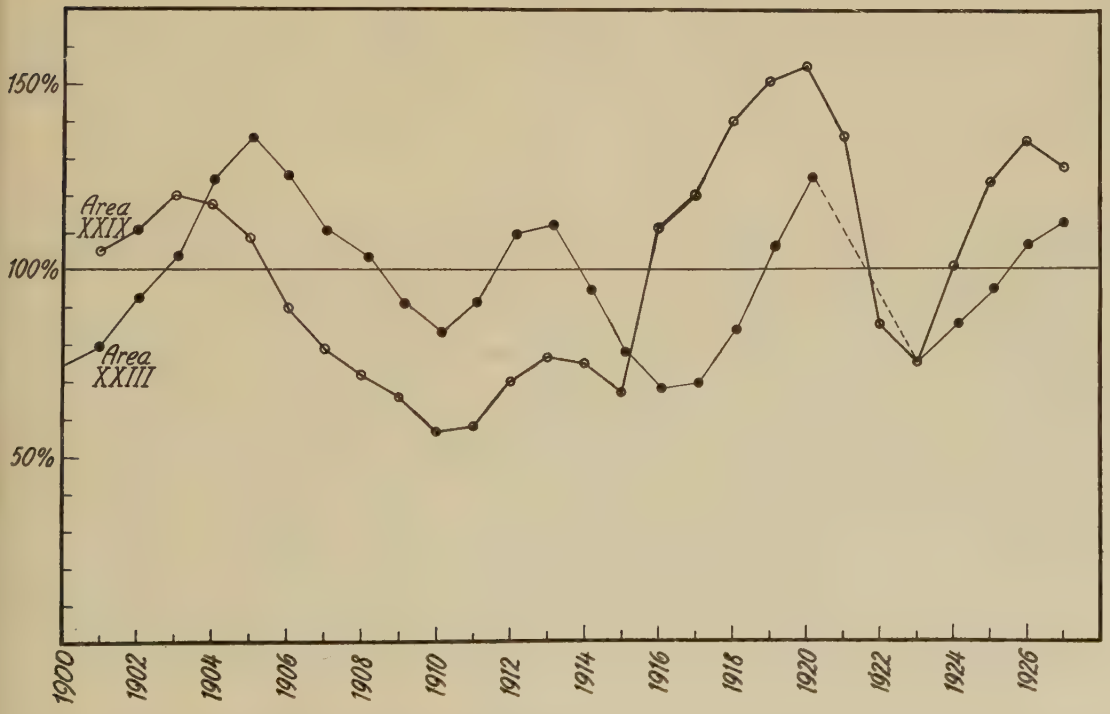


Fig. 5. Area XXIII (off Aberdeen), and Area XXIX (to the southward thereof). Mean Annual Catch of Cod by Aberdeen Trawlers, per 100 hours' fishing. Reduced to percentages of the Mean. (Smoothed curves).

Table III. Mean Annual Catch of Cod by Aberdeen Trawlers, in cwts., per 100 hours' fishing, reduced to Percentages of the Mean for the whole period.

| Area | X | XVII | XVIII | XXIII | XXIX |
|---|---|---|---|---|---|
| 1901 | 56 | 59 | 73 | 82 | 91 |
| 1902 | 60 | 62 | 67 | 91 | 120 |
| 1903 | 91 | 120 | 86 | 106 | 123 |
| 1904 | 135 | 122 | 178 | 128 | 118 |
| 1905 | 135 | 127 | 109 | 152 | 113 |
| 1906 | 126 | 198 | 102 | 129 | 95 |
| 1907 | 99 | 195 | 96 | 98 | 62 |
| 1908 | 92 | 200 | 94 | 117 | 80 |
| 1909 | 106 | 165 | 105 | 98 | 74 |
| 1910 | 129 | 86 | 63 | 69 | 45 |
| 1911 | 144 | 104 | 100 | 86 | 40 |
| 1912 | 154 | 89 | 108 | 120 | 69 |
| 1913 | 167 | 143 | 117 | 124 | 102 |
| 1914 | 91 | 168 | 91 | 97 | 59 |
| 1915 | 80 | .. | .. | 67 | 64 |
| 1916 | 56 | .. | .. | 73 | 78 |
| 1917 | 72 | .. | .. | 67 | 191 |
| 1918 | 80 | .. | .. | 68 | 90 |
| 1919 | 168 | 68 | 107 | 115 | 139 |
| 1920 | 117 | 115 | 114 | 134 | 223 |
| 1921 | 129 | 82 | 147 | .. | 104 |
| 1922 | 105 | 41 | 120 | .. | 80 |
| 1923 | 50 | 36 | 85 | 77 | 70 |
| 1924 | 50 | 27 | 74 | 76 | 74 |
| 1925 | 53 | 32 | 72 | 95 | 158 |
| 1926 | 72 | 24 | 80 | 114 | 139 |
| 1927 | 101 | 38 | 108 | 113 | 117 |

called "impoverishment of the sea". It by no means follows that this is universally true. For instance in the case of Faeroe, our statistics shew at once that the average catches of recent years no longer equal those of the beginning of our period.

In the case of certain fishes, all the various data of which we have spoken can be furnished separately for the chief market-classes (e. g. Large, Medium, Small), though not always for the entire period of years. In the case of Cod we have separate lists for "Codling"; and separate lists also, since 1914, for "Large" and "Small Codling".

The curve for Codling, on area X, is very much like that for Cod (Fig. 6); and it is not possible, yet at least, to say what are the important or significant differences between them. It is certain in all cases, in Cod and Codling alike (but doubtless to a less extent in the case of "Small Codling" than in the others), that more year-groups than one are mixed up. This circumstance must, to some extent, conceal the precise dates of maximal abundance: if it be the case that such maxima are actually the result of certain exceptionally prolific broods.

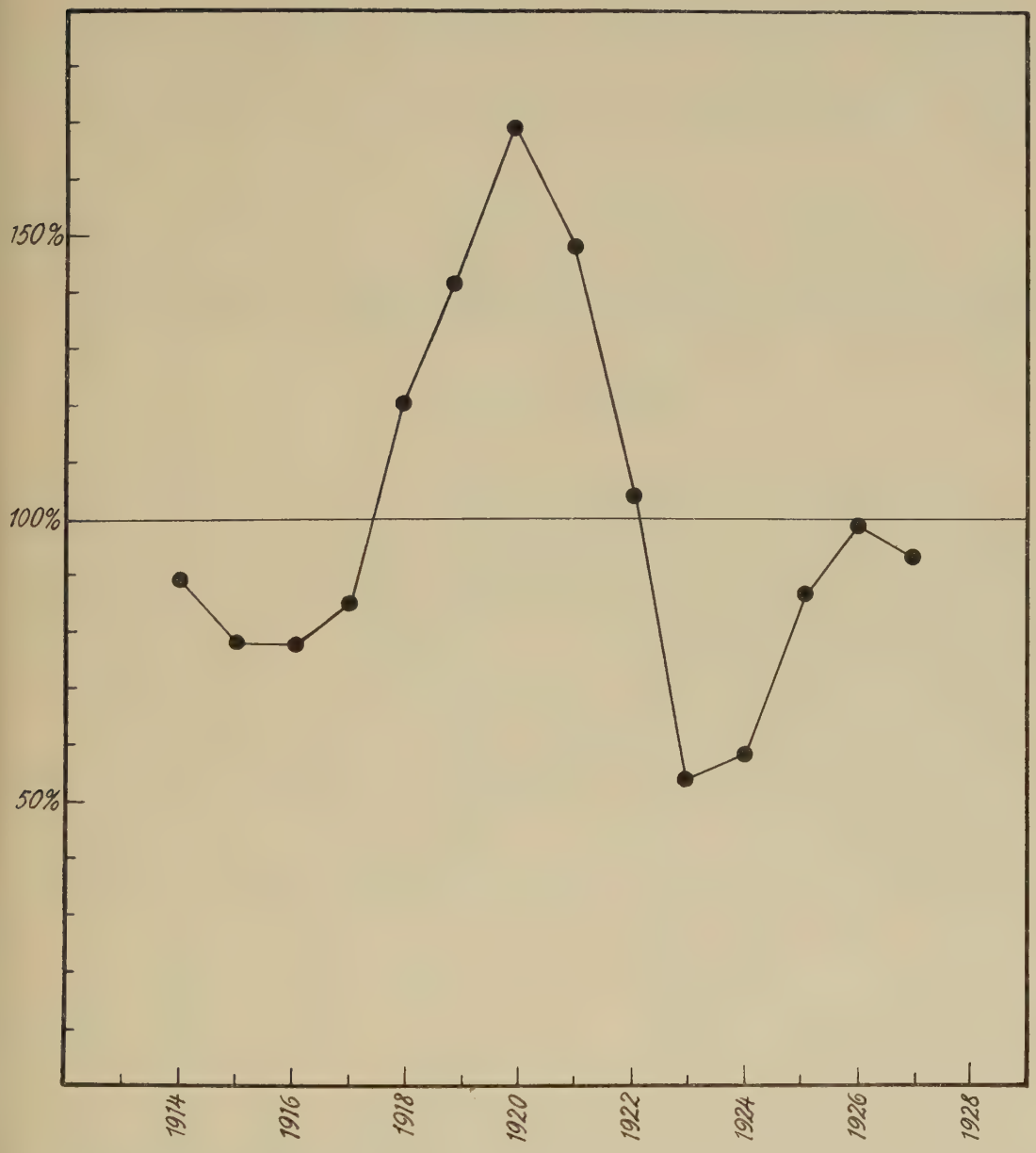


Fig. 6. Area X. Shetland. Mean Annual Catch of Large Codling, by Aberdeen Trawlers., per 100 hours' fishing; reduced to percentages of the Mean for the whole period.

While then our statistics labour under the disadvantage, the obvious and inevitable disadvantage, of ‚lumping together' several year-groups of fish, they are nevertheless, from every other point of view, of great scientific interest and value.

# IV. On the Fluctuations in the Abundance of Cod Fry in the Kattegat and the Belt Sea and Causes of the same.

By

**Erik M. Poulsen.**

Since the spring of 1923 experiments have been made with a two meter ring-trawl in order to investigate the occurrence and frequency of the several species of pelagic fish larvae during the spring months in the Danish home waters. In the following a report will be given of the fluctuations in the quantity of cod fry from year to year and causes of the same. The Danish waters that have been most carefully investigated in regard to the fluctuations in the quantity of fry are the Belt Sea and the Kattegat; we shall therefore confine ourselves to the consideration of these two waters and more particularly the former where the investigations embrace the years from 1923—1928.

In the Belt Sea pelagic fishing was undertaken in April 1923, 1924, 1925, and 1927 and in May 1923, 1926, 1927, and 1928. In the Kattegat investigations were made in the years 1923 to 1927.

The average number of larvae fished per 30 minutes hauls during April and May in the several years was as follows:— (the figures in brackets indicate the number of stations)

| Year | 1923 | 1924 | 1925 | 1926 | 1927 | 1928 |
|---|---|---|---|---|---|---|
| April | 110 (5) | 2 (2) | 67 (6) | — | 63 (15) | — |
| May | 181 (8) | — | — | 5 (10) | 15 (2) | 25 (7) |
| April and May | 153 (13) | 2 (2) | 67 (6) | 5 (10) | 46 (17) | 25 (7) |

In figure 1 a graphic view of the fluctuations is given; the completely drawn curve gives the observations in the Belt Sea made in April 1923, 1924, 1925, and 1927 supplemented with May 1926 and 1928. The dotted curve gives the observations made in the Kattegat in April 1923—1927.

As regards the Kattegat the results were as follows:—

| Year | 1923 | 1924 | 1925 | 1926 | 1927 |
|---|---|---|---|---|---|
| April | 32 (20) | 2 (5) | 46 (21) | 5 (11) | 9 (3) |
| May | 90 (12) | — | — | 8 (10) | 9 (6) |
| April and May | 54 (32) | 2 (5) | 46 (21) | 6 (21) | 9 (9) |

From the investigations here reported, it is clearly to be seen that the years 1923, 1925 and to a somewhat less degree 1927, were good brood years for the Danish home waters while 1924 and 1926 were very bad and 1928 somewhat below normal. The difference in the quantity of larvae from year to year is indeed very great; in 1924 and

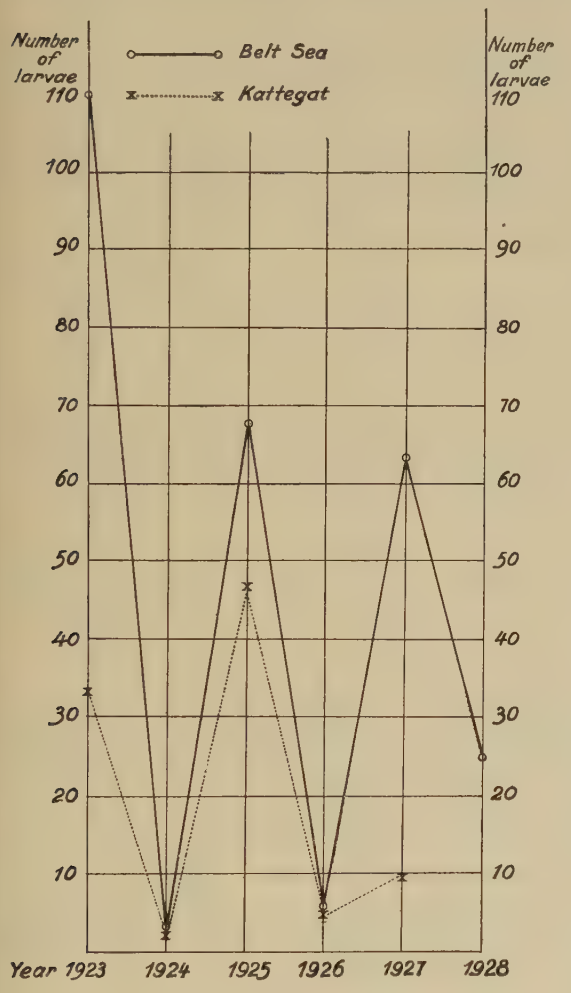


Fig. 1.

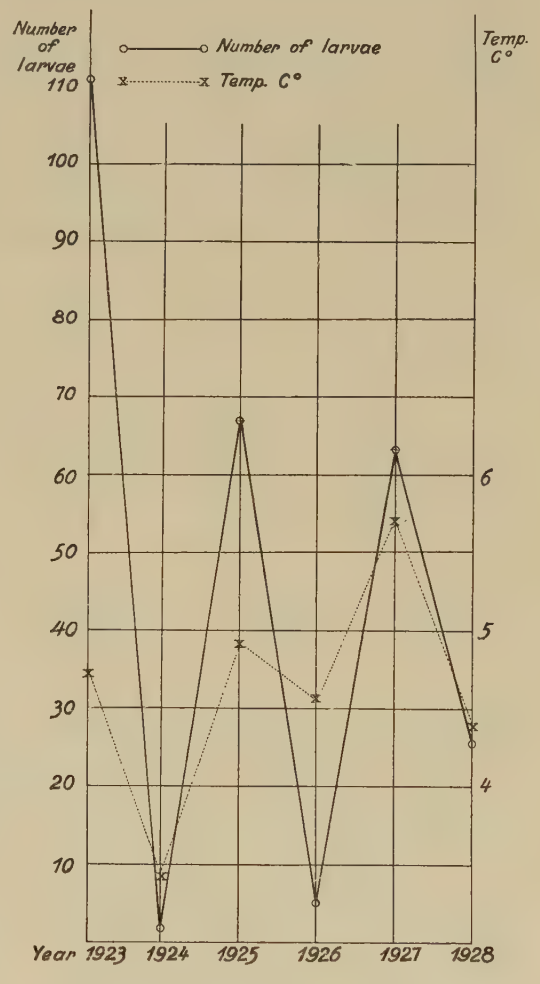


Fig. 2.

Fig. 1. Number of Cod Larvae caught with a 2 metres ring-trawl per 30 minutes in the Belt Sea in April 1923, 1924, 1925 and 1927 and May 1926 and 1928 and in the Kattegat in April 1923—27.

Fig. 2. Number of Cod Larvae caught with a 2 metres ring-trawl per 30 minutes in the Belt Sea in April and May of the years 1923—1928 compared with the Temperature of the bottom water (20 m.) in March, April and May at Halskov Rev Light-vessel.

1926 such low averages as 2 and 5 are to be found while the average of larvae in 1925 is 67 and in 1923 as much as 153.

The reasons for these great fluctuations must be sought in certain hydrographical

conditions. As the cod larvae are to be found preeminently in the lower layers of water it must be assumed that first and foremost it is the hydrographical conditions in these lower layers of water that determine the quantity of the larvae.

Through daily observations made from the light-ship Halskov Rev[1]) which lies on 20 metres depth in the Great Belt, a notion can be formed of the variations in temperature and salinity in the Belt Sea. From an examination of the fluctuations of the temperature of the water at the bottom it will be seen that these fluctuations agree with those in the quantity of fry as regards the months of March, April and May (that is to say in the months during which by far the largest number of cod larvae are found in the Belt Sea) and in this way, that the higher temperatures in these months coïncide with the large quantities of fry and vice versa. This circumstance is graphically shown in Fig. 2 and the corresponding figures are given here:—

| Year | 1923 | 1924 | 1925 | 1926 | 1927 | 1928 | Aver. for all years |
|---|---|---|---|---|---|---|---|
| Number of larvae per 30 min. .... | 110 | 2 | 67 | 5 | 63 | 25 | 45 |
| Average temp. C° March to May... | 4.7 | 3.4 | 4.9 | 4.6 | 5.6 | 4.3 | 4.4 |

A similar agreement exists as regards the Kattegat where, however, investigations for 1928 are missing. The results from the Kattegat are as follows:— (The temperature measurements are from the water at the bottom by the Anholt Knob light-ship for March, April and May.)

| Year | 1923 | 1924 | 1925 | 1926 | 1927 | Aver. for all years |
|---|---|---|---|---|---|---|
| Number of larvae per 30 min. April to May | 54 | 2 | 46 | 6 | 9 | 29 |
| Average temp. C° March, April and May ... | 6.0 | 3.1 | 5.3 | 4.7 | 5.1 | 5.0 |

Now it is a question whether the temperature acts directly or whether it acts indirectly by exerting an influence on the quantity of the nourishment (Plankton) produced in the sea so that higher temperatures are more favourable for the production of the nourishment than lower temperatures. For the development of plaice fry it is already shown[2]) that the quantity of plankton plays an important part in the survival of the fry and it must be considered probable that the same is the case as regards cod fry.

A really distinct agreement between the temperature at the bottom and the quantity of fry cannot be shown for other months than the spring months mentioned here; there is, however, some agreement between the temperature of the surface water in January and February and the quantity of fry in the springtime.

Another hydrographical factor which might be considered to exert an influence on the survival of larvae is the salinity. We shall here again begin by examining the conditions in the lower layers of water where the larvae preeminently live. The investigation shows that there is little or no agreement between the salinity during the months of February to May (that is to say, just the very period that larvae are found) and the quantity of larvae. On the other hand there is a particularly distinct agreement between

[1]) Nautical-Meteorological Annual published by the Danish Meteorological Institute, Copenhagen.

[2]) A. C. Johansen: On the Fluctuations in the Quantity of Young Fry among Plaice and certain other species of fish, and causes of the same. Report of the Danish Biological Station XXXIII, I, 1927.

the salinity of the water at the bottom during the months of November, December and January (to a minor degree October) and the quantity of fry in the following spring as a high salinity in these months is followed by large quantities of larvae while a low salinity is followed by small quantities of larvae. This circumstance is shown in Fig. 3

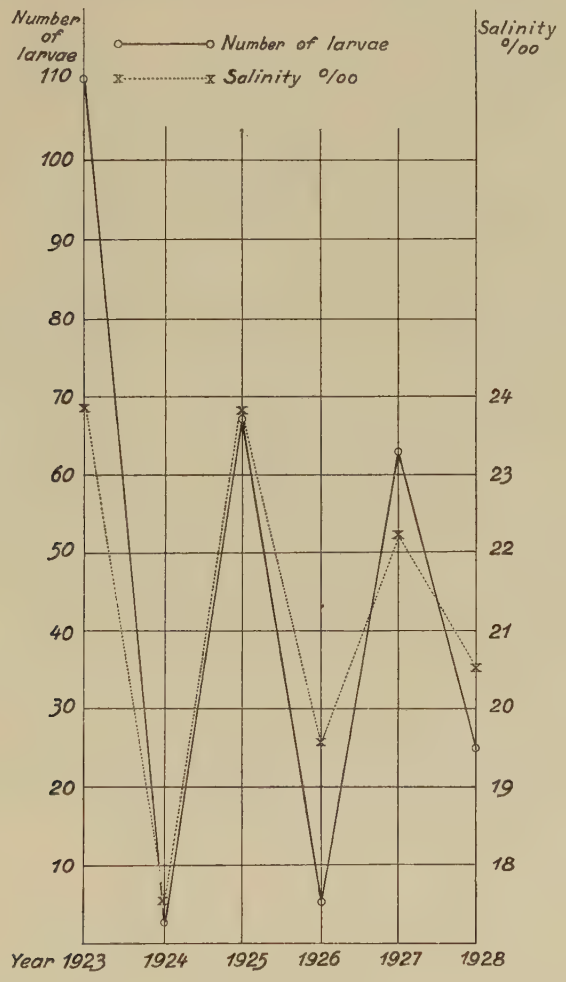


Fig. 3. Number of Cod larvae caught with a 2 metres ring-trawl per 30 minutes in the Belt Sea in April and May of the years 1923—1928 compared with the Salinity of the bottom water at Halskov Rev Light-vessel in the preceeding November, December, and January.

and the corresponding figures are as follows:— (The salinity is measured from the light-ship Halskov Rev, at the bottom.)

| Year | 1923 | 1924 | 1925 | 1926 | 1927 | 1928 | Aver. for all years |
|---|---|---|---|---|---|---|---|
| Average of larvae per 30 min. | 110 | 2 | 67 | 5 | 63 | 25 | 45 |
| Aver. salinity in November, December and January, per cent | 23.8 | 17.2 | 24.2 | 19.5 | 22.3 | 21.1 | 21.4 |

A similar agreement exists as regards the Kattegat as will be seen from the following figures:— (Salinity is measured from the Anholt Knob light-ship, at the bottom.)

| Year | 1923 | 1924 | 1925 | 1926 | 1927 | Aver. for all years |
|---|---|---|---|---|---|---|
| Number of larvae per 30 min. | 55 | 2 | 46 | 6 | 9 | 29 |
| Aver. salinity in Nov., Dec., Jan., per cent... | 29.9 | 26.1 | 30.8 | 29.1 | 30.3 | 29.2 |

The agreement between the course of the two curves is for the Belt Sea exceedingly great. Here, however, there is no question of a direct effect; the spawning of the cod in the Belt Sea begins in January, and in these waters it reaches its maximum in February and March. The agreement can here possibly be explained in the following manner:— In the autumn a migration of large cod takes place from the Kattegat and Skagerak to the Belt Sea. These cod again emigrate in the course of the winter; we cannot tell whether they migrate back before or after spawning. But if this emigration usually takes place before the spawning, for instance, in December and January, it is possible that a strong inflow of salt water from the north in the said months will cause a delay in the time for emigration so that these cod spawn in the Belt Sea. If on the other hand the emigration does not take place until towards the spring, after the spawning, a strong inflow of salt water in November to January might cause a great number of cod to make their way into the Belt Sea and thus increase the intensity of the spawning.

We have now seen that the fluctuations in the temperature and salinity from year to year coïncide with the fluctuations in the amount of cod fry developed. It is now of interest to know how far the amount of fry developed in a certain year is of importance for the stock of cod in the following years. Fishing experiments carried out with a small and finemeshed ottertrawl in the Danish waters in the years 1923—1928 have shown that there is a strong correlation between the number of larvae in the spring and of the 0-group in summer, and for a longer period, 1917—1928, there has been found a similar correlation between the abundance of the 0-group in one year, the I-group in the following and the II-group in the next following year.

# V. Observations on Cod Eggs.

By

**Gunnar Rollefsen,**

Norwegian Directorate of Fisheries, Bergen.

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During the winter cruise of the Norwegian Fishery-Research Cutter to the Lofoten waters in 1928, it was observed that the embryos in a good number of cod eggs had an abnormal shape and position.

The examination of the material both from that and previous years gave the result that deformed embryos were very common, and if the catch consisted mostly of young eggs nearly 95 per cent. of them were found to contain such embryos.

In the spring of 1929 opportunities were provided for making these facts the object of further inquiry on living cod eggs. The material was collected in the usual way by surface hauls with a 1 meter plankton net, silk 0.

As soon as the catch of eggs was put into a glass with seawater, it divided into two layers, one floating, while the other sank down to the bottom.

This had, of course been observed often enough before, but now a closer examination showed that all eggs laying at the bottom of the tumbler contained deformed embryos, whilst the embryos in the floating eggs were normal. When preserved in 4 per cent. formalin, the yolk of the sunken eggs coagulates very quickly in contrast to the yolk of the floating and normal eggs which remains transparent for a long time. The deformed embryos look quite fresh, none of them showing symptoms of putrefaction. The decay however begins in the course of a few hours. And whereas the floating eggs continue their regular development none of the sunken do so.

The cod eggs were kept in small glass dishes during the experiments. Once or twice some eggs in these dishes appeared with misshapen embryos which must have originated there and then from normal ones. The eggs kept in these dishes were now and then cleaned in a small sieve, under a jet of clean seawater, to get rid of any growing diatoms, and this treatment was possibly the cause of the changes taking place inside the eggs.

A couple of normal eggs were shaken in seawater, and this treatment produced embryos that were misformed in the same manner as those appearing in the net hauls, and they showed at once a tendency to sink. The whole process took only a few minutes.

If a shaken egg is put under the microscope as quickly as possible, a considerable part of the process can be followed. The thin membrane that covers the yolk (*Membrana Vittelina*) is torn, and as the yolk streams forth and fills the space inside the egg-capsule,

the yolkmembrane collapses entirely, and the embryo, extending over the yolk, breaks down and shrinks, especially the epithelium which tends to envelop the yolk, fig. 1.

The yolk seems to be under relatively high pressure, and the yolkmembrane normally under a certain amount of stress, and possesses a great degree of elasticity, as it will, when torn, cause the germinal disc as well as elder embryos to shrivel into a small twisted knot.

The appearance of deformed embryos in eggs from the net hauls is now explained in the following manner.

Fig. 1.

The eggs are quite normal up to the instant they are caught in the net. During the subsequent towing the eggs are exposed to shakings and pressures in the net and a very great deal of them get their yolkmembranes damaged.

Various shaking experiments were carried out with the cod-eggs. In one experiment was used a glass cylinder (diameter 6 cm., length 50 cm.) closed up with a cork in each end. This cylinder was fastened to a vertical disc. A couple of normal eggs and a small portion of seawater were put into the cylinder. When the disc now was set in a slow rotation, the water and the eggs ran from one end of the cylinder to the other. Only a few turns proved sufficient to produce the misformed embryos.

The sensitiveness appeared to be highest in young eggs, from 1st to 6th stage (when the whole development is divided in 12th stages). There seems to be a decrease in the sensitiveness when the yolk is fully covered with embryonal tissue. In this as well as in other shaking experiments that were carried out, the eggs might strike against

the glass or cork. No experiments were made where this could be avoided. It may, however, safely be concluded from the above, experience that even very slight knocks and stresses are sufficient to injure the eggs.

As mentioned before the eggs begin to sink when the yolk comes in contact with the eggcapsule. As the sinking must be due to an increase of the specific gravity, either a reduction of the volume or an increase in weight must occur. A decrease in volume has not been proved and owing to the properties of the eggcapsule it is less probable. There is, however, every proability that an increase in weight takes place. It is conceivable that the eggcapsule, after the distruction of the yolkskin, is unable to prevent an exchange of substances between the yolk and the seawater.

The question then arises whether the eggs and fry of the cod are exposed to such strong disturbances in the sea that they are destructed and if so, whether these influences are of such a nature that their occurrence will vary from year to year.

Should these suppositions be found to hold good, it is well conceivable that the relative occurrence, of disturbed surface water may be a contributory cause to the fluctuations in the stock of the cod.

As the cod eggs float very near the surface it is not unreasonable to suppose that they follow the breakers when the sea runs high, and thus with very heavy force are again hurled into the water, and that the changes of pressure and speed to which the eggs in this way are exposed cause their yolk membrane to burst and thus kill the embryos.

It is now of a certain interest to see whether the meteorological facts favour this supposition. It must however be noticed that in the Vestfjord the south and west winds cause the heaviest sea and are of greatest force. The north and east winds are landbreeze and do not as a rule cause heavy sea, on the spawning areas.

Fig. 2 gives the average frequency of S., SW. and W. winds at Røst (Lofoten), from 1907 to 1927, in the spawning months of the cod, i. e. February to April, and also the average temperature of the air in the same season. As it will be seen it has been hot in the years with high frequency of south to west winds, and on the contrary colder when the frequency has been lower.

From the investigations of Mr. Oscar Sund on the fluctuations in the stock of the cod we know that the yearclasses 1909, 1912, 1915, 1917 and 1919 have been comparatively rich. Comparing this with fig. 2 we will see that these years are characterized by having a low frequency of south winds and low temperature. As previously shown by Mr. Sund, the birth years of the good yearclasses are distinguished by light precipitation in the months December to March, facts very well compatible with what is mentioned above, southerly winds bringing downfall and high temperature while the northerly winds are dry and cold. Mr. Sund regards the light downfall to be an indirect cause of a rich plankton production and thus providing one of the conditions necessary for the fry to thrive.

The causes of the fluctuations in the stock of cod may be many and there may be many conditions necessary for a successfull brood.

The apparent connection, however, between the production of rich yearclasses

and certain meteorological conditions during the spawning season is of great interest. The nature of this connection may contain more elements than those suggested or mentioned here. It is, for instance, very likely that the currents which appear as consequence of prevalent winds may carry the eggs to localities favourable or unfavourable to their development.

If opportunities are afforded this research will be continued next year. The main question to be solved, by as direct methods as possible, is whether the influence of breakers

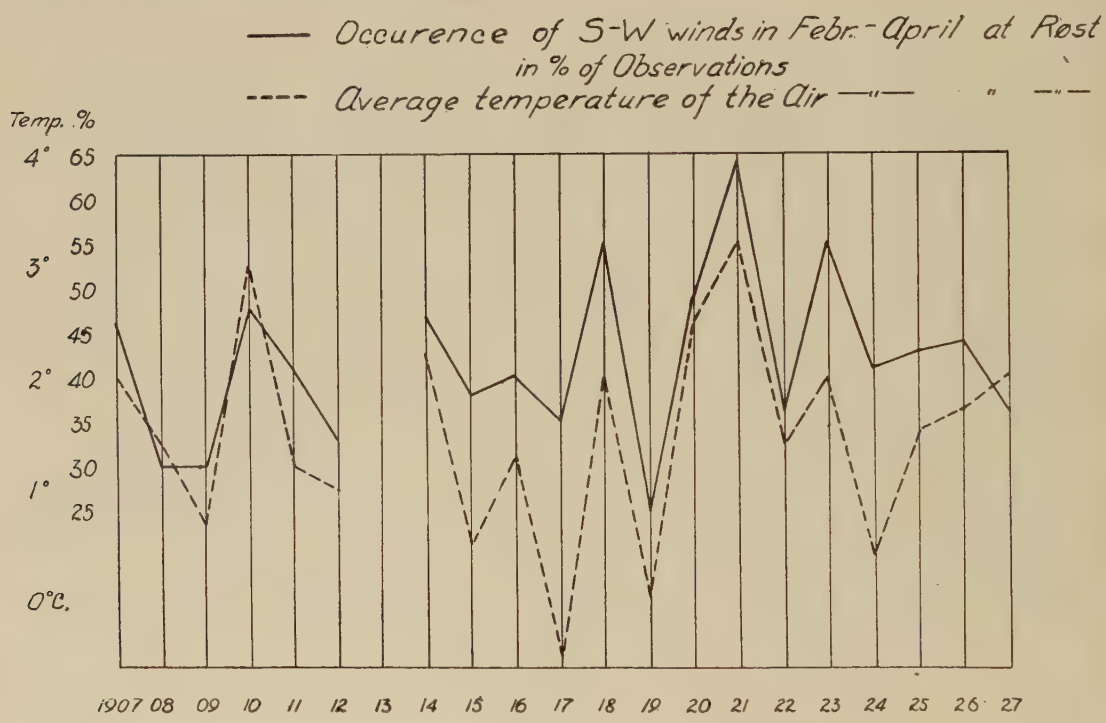



Fig. 2.

has a destructive effect on the eggs. Then comes the task to try to measure the degree of pressure or/and acceleration necessary to produce injurious effects.

It is moreover desireable to find out why the eggs sink, their specific gravity and rate of development at different temperatures.

Regarding other species of fish it may be mentioned that the same kind of misshapen embryos have been seen in the eggs of torsk, coalfish and some species of flat fish.

It is of interest to observe that all the eggs where such misformed embryos have been found belong to the type having a small perivitteline space, never in such eggs as for instance *Drepanopsetta* where a big open space is found between the shell and the egg proper.

# VI. Fluctuations in the North Sea Haddock Stock.

By

**Harold Thompson.**

After the first few months of its life the Haddock may be described as dwelling mainly within a few feet of the sea floor. It is therefore natural that the Otter Trawl has proved to be by far the most efficient instrument for capturing Haddock of all but the very smallest sizes. Used on the large scale the Trawl has been demonstrated to yield results of high value for the purpose of quantitative studies. (1) The great commercial trawling fleet, with its continuous and widespread activities, provides the most comprehensive available statistics relating to the stock of Haddock in the sea. Unfortunately we are not yet in a position fully to utilise these statistics. When we are, it is reasonable to assume that the results of quantitative studies will be even more consistent than those which, based chiefly on the more restricted operations of the research vessel, will now be considered.

Fig. 1 shows that, by use of the methods of estimation which have already been outlined (2) the recent North Sea annual broods have each been found to retain throughout life very much their initial relative order of numerical density. This they have done with a degree of consistency which is a remarkable proof of the reliability of scale-age determination as a means of stock-analysis. The figure demonstrates, for example, that the 1923 year-class, age for age, gave the highest returns year after year, and the 1922 year-class the lowest. Of the two very scanty broods that of 1921 retained its slight advantage over that of 1922 for the seven years covered by this study.

Now this natural variation in accession of new brood Haddock may be correlated with the actual results of the commercial fisheries. The latter was reliably portrayed in the curve in Fig. 2, which as described in (2) shows the monthly variation in the weight of the average North Sea commercial catch in unit time. Below the curve, for the sake of simultaneous comparison, are represented the relative frequencies of the recent broods. These frequencies are based on the average numbers of the broods appearing in the research vessel catches (chiefly) during the first three years of the life of each brood. (The method of computing these averages, and the reason for including only the first three years of life, are given in (2)).

The weight curve can be shown to follow a course intimately related to the variation in the success of the broods. First of all, however, we must discount seasonal rises and

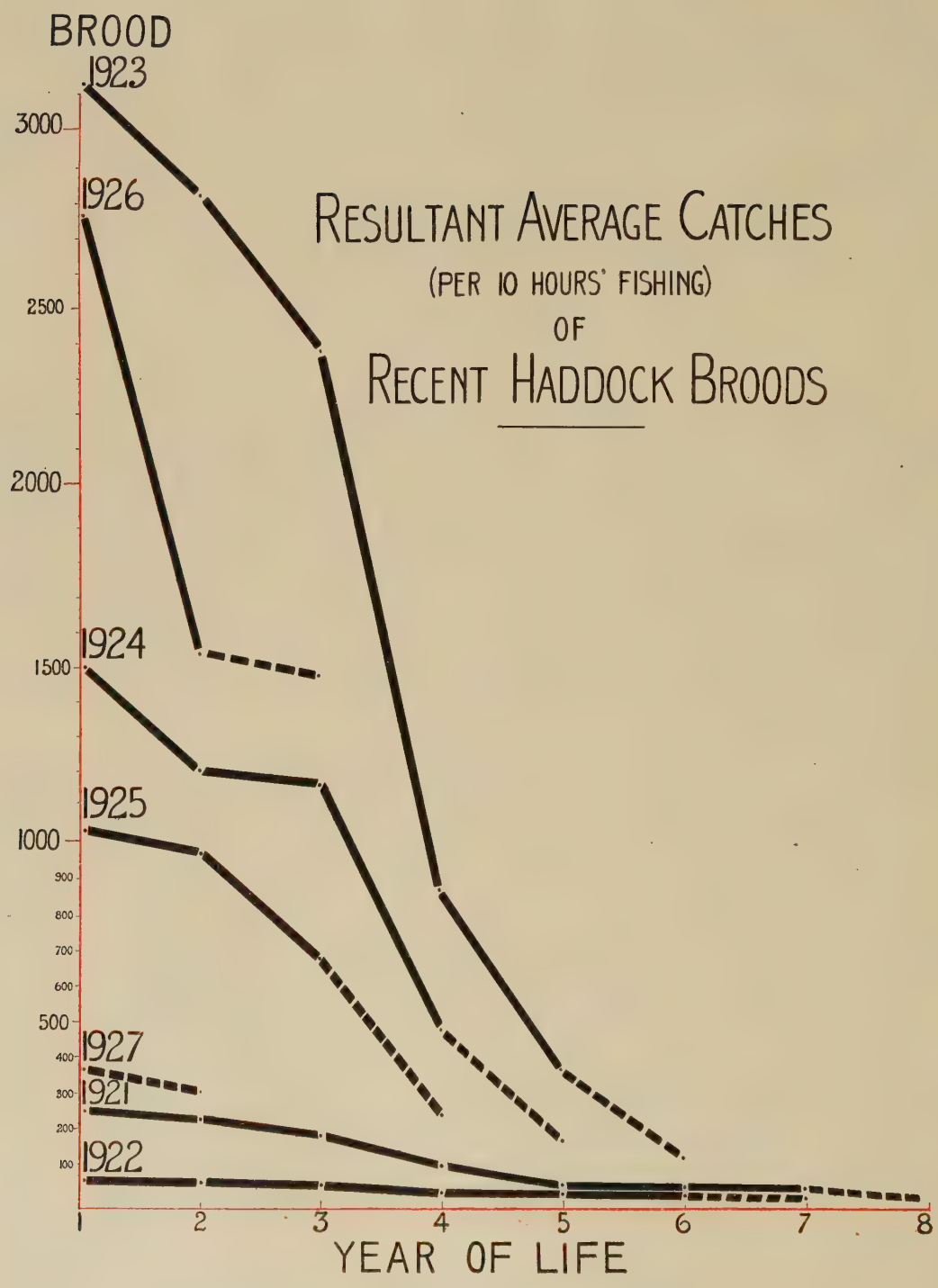
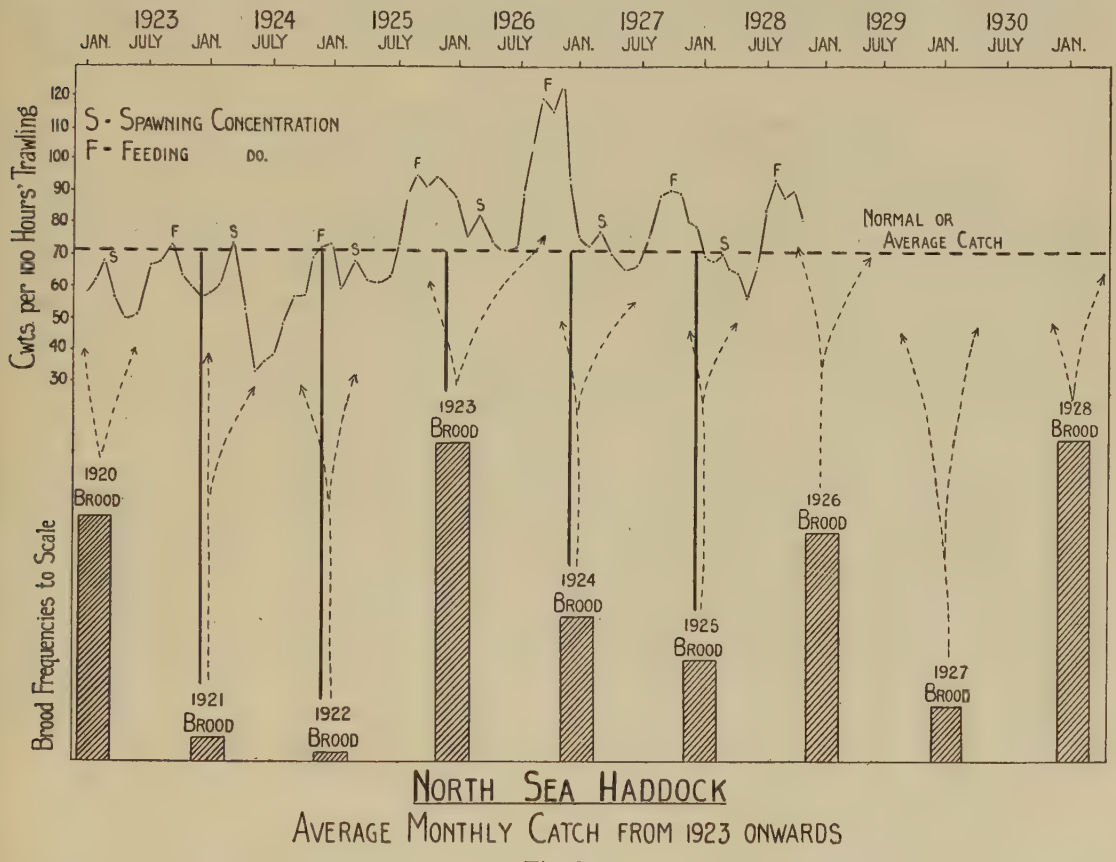

BROOD
1923
1926
1924
1925
1927
1921
1922
3000
2500
2000
1500
1000
900
800
700
600
500
400
300
200
100
1
2
3
4
5
6
7
8
YEAR OF LIFE
RESULTANT AVERAGE CATCHES
(PER 10 HOURS' FISHING)
OF
RECENT HADDOCK BROODS

Fig. 1.

falls in the weights. Thus there is each year a minor rise in March (at the height of the spawning concentration) and a more pronounced rise in autumn (at the height of the feeding concentration). Conversely, each year there is a fall during the periods of migration to or from the spawning and feeding grounds. In short, Haddock are presumably most gregarious and nearest the sea floor during the spawning and feeding seasons, and least gregarious (or: and higher off the sea floor) during the intermediate seasons of




North Sea Haddock

Average Monthly Catch from 1923 onwards

Fig. 2.

migration. But the great variability from year to year in the amount of recruitment by young fish emphasises these rises and falls in the weights to be caught. Arrows have been inserted in Fig. 2 to show the approximate points at which the various broods appreciably affected the catches.

The period reviewed here commences in 1923, when the comprehensive weight statistics referred to first became available. At that time the 1920 brood was in its fourth year and had by the autumn of the year been largely fished out, and since stock replenishment by the 1921 and 1922 broods was singularly lacking, catches dwindled to the point of scarcity in 1923 and 1924. A recovery set in during the autumn of 1925, and was entirely due to the fact that the plentiful 1923 brood fish were then reaching market-

able size. The further upgrowth of this brood sufficed still further to raise the level of the catches in 1926. At the time of maximum feeding concentration the average weight caught in unit time was as much as 70 per cent. greater than in the corresponding season in 1923 or 1924. But by the end of 1926 the 1923 brood had been depleted to the extent of about 75 per cent. of its numbers, and since the 1924 and 1925 year-classes were only moderately numerous the catches rather sagged away towards 1928 — although not to the point of causing complaints of scarcity of Haddock. As the 1926 brood was, however, more than usually successful an improvement set in in the autumn of last year (1928).

### Regions sustaining independent Haddock Stock.

In making computations such as these it is essential to treat separately those regions which, bounded by water of greater depth than 300—350 meters, maintain Haddock stocks which may for all practical purposes be regarded as being independent. Such virtually independent regions are the North Sea, the grounds to the north of Ireland, Rockall Bank, Faroe Bank, Faroe, Iceland, the Norwegian plateau, and the grounds off the East North American coast. The Haddock of each of these regions have their own characteristic rate of growth, and this is accompanied by recognisable peculiarities of scale structure. Moreover, the years of incidence of the very successful and the unsuccessful brood years in any one of these regions differ from those in any other. Again, what may be termed the average shoal density of one region differs from that of another. Thus the North Sea yields, on the average, smaller catches in unit of time than does Faroe, Faroe smaller than Iceland, and Iceland in turn smaller than the White Sea or Rockall Bank. On biological grounds, then, as well as from the study of the years of incidence (and the relative shoal density) of the successful broods, one is urged to treat these regions individually. At the same time it remains an open question whether minor interchange occurs in certain cases — e.g., by the occasional drift of pelagic fry from the margin of the North Sea to the Norwegian plateau, or by the passage, in later life, of large Haddock from Faroe Bank across the narrow Channel to Faroe.

### The Incidence and Amplitude of Fluctuations in Brood Survival.

In the North Sea in the recent years prior to 1928 the most numerous brood was that of 1923. Reckoned on the basis of yield in unit of fishing time this brood outnumbered that of 1922 by more than 50 to one (2). The other year-classes gave yields placing them at various points between these extremes of success and non-success. Scientific investigations, coupled with observations on the actual results of the commercial fishing, point to the conclusion that in the North Sea, since the year 1901, highly successful broods have occurred at intervals varying from four to seven years, and averaging from five to six years. In regions where the mean shoal density exceeds that of the North Sea the interval appears to be shorter — e.g., at Iceland to vary round three years. On the contrary, where, as in the grounds to the north of Ireland, shoal density is low, the interval is more prolonged, and probably of the order of from 10—15

years. The upshot in this case is that when a time of greatly increased catches occurs it evokes considerable comment, and searching of memory takes place to recall the occurrence of similar events in the past.

## Possible Causes of Fluctuations.

Certain possible causes of these great fluctuations suggest themselves. Indeed some measurement can be made of the variation in certain factors which assumedly affect the course of events at the spawning season. Take, for example:—

### (a) The Variation in the Location of the Spawning Grounds.

We may regard the annual northerly spawning migration as terminating at a fulcrum, or line north and south of which there occur equally dense shoals (as reckoned by weight of catches taken in unit time by commercial vessels). In recent years this fulcrum has varied in position by the large amount of nearly 2 per cent. of latitude.

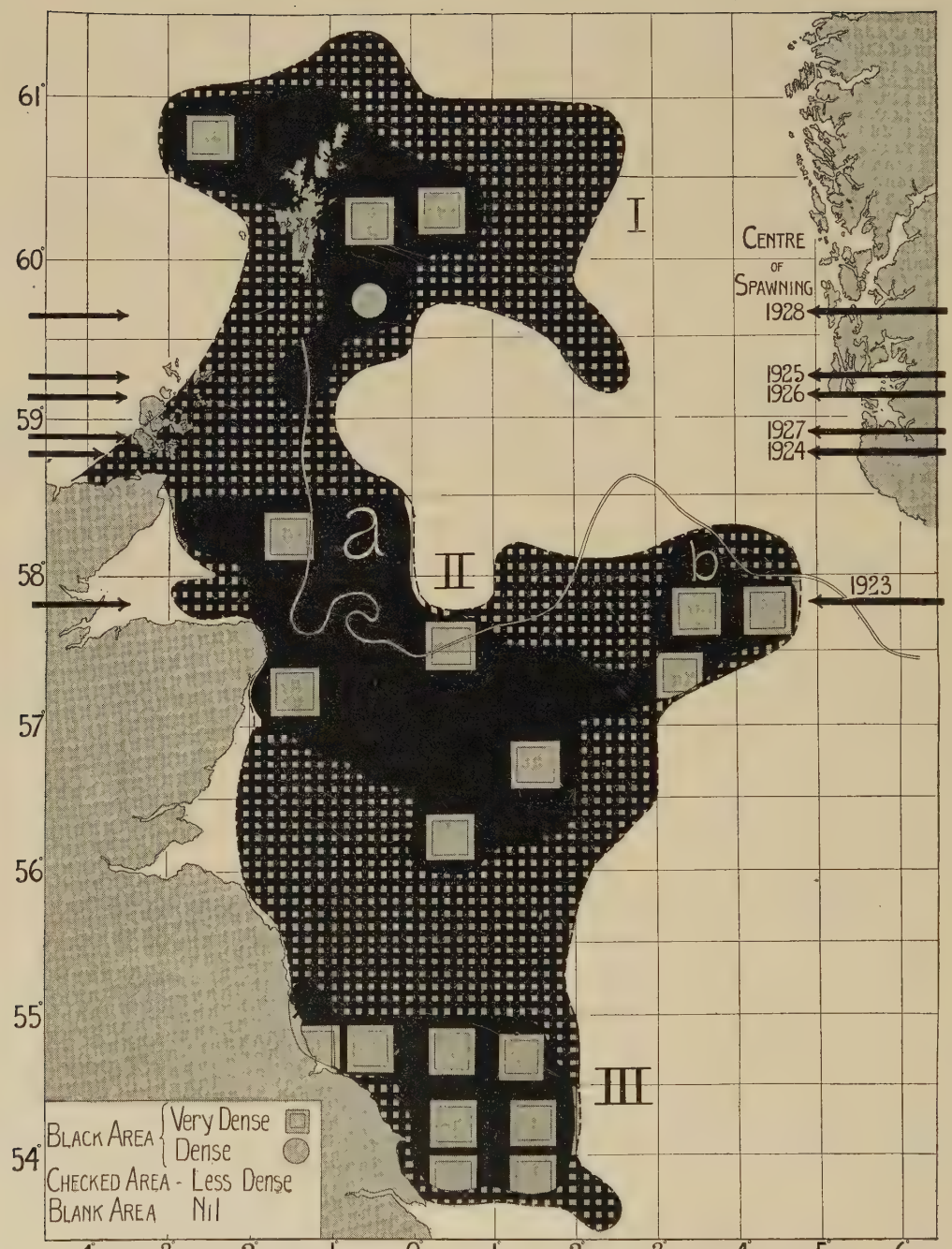
(e.g.:— in Fig. 3, from just south of 58° to just south of 60° N. L. in 1923 and 1928 respectively. In the remaining years the fulcra approximated to a position intermediate between these extremes.)

Since, however, the 1923 and 1928 spawning seasons have been the most successful it would seem that it is not a matter of critical importance to brood survival whether the spawning shoals assume a very southerly or a very northerly position. What effect there is is rather indirect and delayed, in that the subsequent primary distribution of the fry is influenced. Thus we know that the unusually southerly position of the spawning shoals in 1923 was followed by a more than normally southerly distribution of the new brood of that year.

(In Fig. 3 the usual distribution of first year Haddock is shown to be over areas I and II. In 1923 area I was poorly recruited but area III in the south was very fully restocked. From this abnormally advanced first year outpost in the south the 1923 brood spread during its second year to all portions of the shallow south and east North Sea, grew rapidly in such shallow water to a commercially valuable size and suffered early exploitation. It is a reasonable speculation that the 1928 brood — equally prolific in numbers but, probably on account of the more northerly position of the parent spawning shoals, having a more northerly cast than that of 1923 —, will be of less immediate but more lasting benefit to the general Haddock fisheries.)

### (b) The Numbers and the Average Age of the Spawners

are other variants which are measurable year by year. The spawning shoals are always comprised chiefly of Haddock of from 3 to 6 years of age, and therefore include a series of broods differing among themselves in initial numerical strength. To a considerable




DISTRIBUTION OF HADDOCK IN THE FIRST YEAR

Fig. 3.

extent therefore the effect of good and bad brood years is smoothed over in the aggregation of fish of different ages in the spawning shoals.

(Reverting to Fig. 2, we note that the fluctuations in the average catches are most marked during the feeding season, when the upgrowing young and mostly immature fish of ages 2—3 which compose the major portion of the stock on the feeding grounds are being fished. Less fluctuation is, however, shown to occur in the spawning seasons, prior to which fishing operations have for at least eighteen months been instrumental in levelling down even the great numbers of a prolific brood like that of 1923. It is for this reason that there is represented in the catch-curve such an apparent anomaly as the unusually large catches during the feeding season of 1926 and the almost normal catches during the spawning season of 1927 a few months later.)

The average age of the spawners, and therefore their average weight (upon which their average egg-production probably depends) do not then appear to vary sufficiently to be factors of first importance in causing fluctuations. But they may aggravate the effects of other more important factors.

(Compare, for example, in Fig. 4 the composition of the spawning stocks of 1926 and 1928. In 1926 the greater proportion of the spawners were three years of age, 4's and 5's being almost entirely lacking. In 1928, however, the combined weights of the 4's and 5's far exceeded that of the 3's.)

Now there is quite an appreciable difference between the spawning locations assumed by the younger fish as compared with those taken up by older Haddock.

(This is exemplified in Fig. 8 of (2). Young spawners are generally distributed over the whole area of the northern North Sea, but if anything more densely towards the west. Older spawners, on the other hand, tend to group themselves near the eastern and northern periphery of this area.)

The outcome may well be that eggs and fry resulting from the spawning of the younger fish predominating in one year will drift in quite a different set of currents than will those resulting from the spawning of the older fish predominating in another year.

The consideration of the more or less measurable factors treated of under (a) and (b) has, however, failed to account for the enormous variations in the survival values of the different year broods. At what point in the life history of the young Haddock is great danger liable to occur? We know that once the pelagic stage is safely passed there is no catastrophic reduction of numbers owing either to famine or to destruction by natural enemies. It is significant, for example, that after the young Haddock of a brood reach the demersal stage their numbers are well sustained for the remainder of the first year. Again, Haddock have a catholic taste in food, and the young shoals invariably manage to attain the same local average size by the end of the first year. Further, if the earlier (fry) stage be considered, it seems to be at least improbable that natural enemies — the herring for example — could over an entire region remove in any one year the greater proportion of the brood, yet in another year leave the brood numbers

apparently almost intact. It seems then that we must look for limiting conditions still earlier in the life cycle — e.g., during the early pelagic life. Adequate egg-production would appear to be provided for, since the total weight of spawning fish has been shown

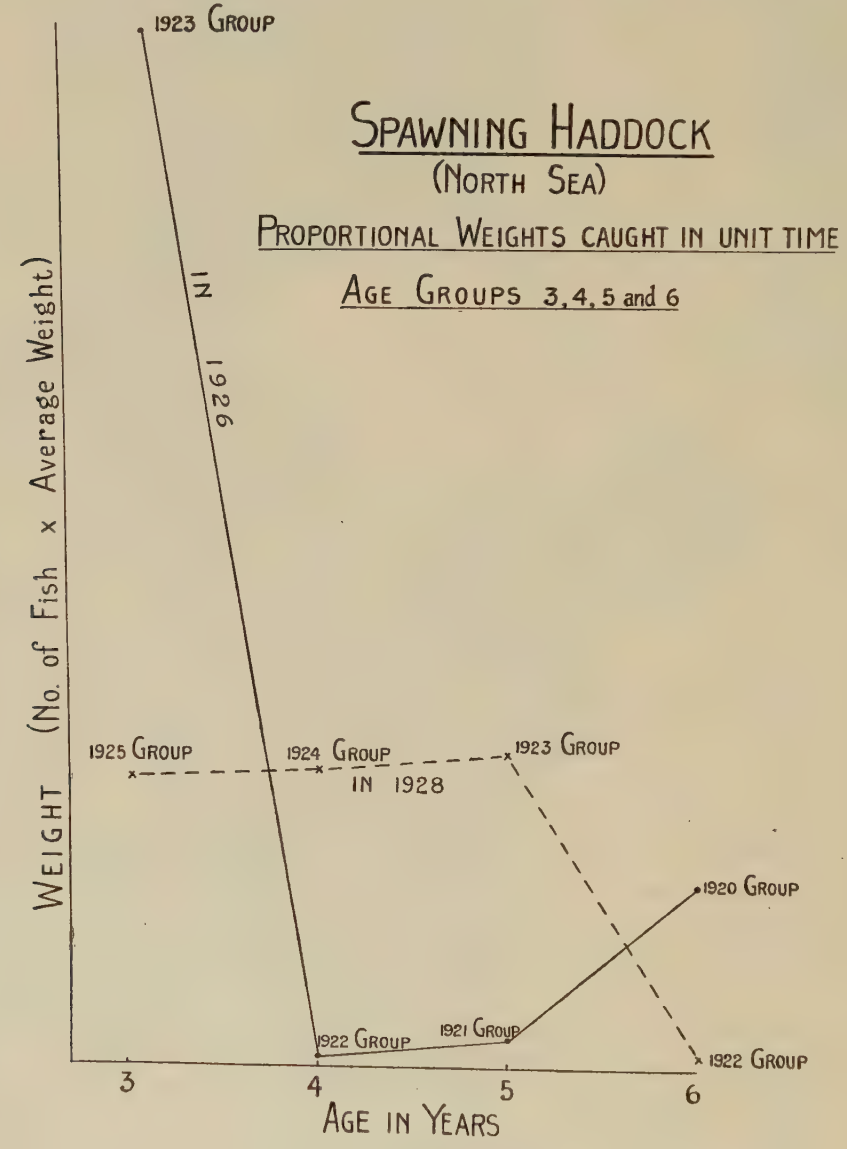



Fig. 4.

to vary within narrow limits. The hatching of the larvae can take place within wider limits of salinity and temperature than occur in the waters overlying the spawning grounds, so that larvae should always abound. It is almost certain then that the most critical period in the life history of Haddock is that when the reserve material remaining

over from the egg is exhausted and the first extraneous food supply has to be found. It is possible that the early food requirements are highly specialised and likely to be in short supply to varying degrees in certain years. No other explanation of the wholesale failure of a brood suggests itself. Partial failure could be accounted for on the theory that in certain years unfavourable currents bear a fair proportion of the fry in a direction precluding their distribution as early bottom stages over the body of the North Sea.

The major variations in the current systems of the waters overlying the spawning grounds are still unknown, but by plotting out as fully as possible the distribution of the early bottom stages of the Haddock year by year we are really gathering a growing volume of indirect evidence on this subject. When that evidence is sufficient to enable the normal and the variations therefrom to be distinguished we will be in a position to direct investigations with economy of effort towards gaining a more complete understanding of the primary natural cause or causes of fluctuations in brood survival.

## The Effect of Fishing Operations on a Stock subject to wide natural Fluctuations.

The results of these natural fluctuations were felt by fishermen before intensive trawling was instituted. But the occasional occurrence of a period of real general (as opposed to local) scarcity of Haddock was less to be feared than it is now, when the succession of two year broods of poor survival value (those of 1921 and 1922 for example) can give rise later on (as in 1923 and 1924) to lean times for the deep sea fisherman. Under present conditions the fishing is chiefly one for small and medium Haddock of ages 2 to 4. More than three-quarters of the original numbers of a brood seem to be removed before the end of the fourth year. No reserve of older fish is allowed to accumulate to tide over bad times. Haddock may be expected to be really plentiful only at intervals of from 4 to 7 years, according to the incidence of the very successful broods, and it is obvious that by fishing out the bulk of these broods by the end of the fourth year we are allowing for only the shortest of these intervals. It is therefore obvious that when we encounter one of the longer intervals between good brood years scarcity will be felt. Scarcity or plentifulness will always be most apparent in the southern half of the North Sea — the great feeding area where, as Fig. 2 shows, great toll is taken of the younger fish. In the northern and north-western (i.e. the spawning) area fluctuations are more masked for the reason already given, and also since there is a pronounced tendency for mature Haddock to remain in northerly waters after their spawning migration thither, so that the stock comprises a greater range of broods. Even here really large Haddock are, except after a recuperative period such as the war provided, comparatively scarce, though there is a sufficient stock of medium and large Haddock of age 4—7 to prevent great fluctuations being caused in the catches owing to the varying success of the individual broods.

By studying the existing composition of the North Sea Haddock stock we may, with the aid of Fig. 2, form an estimate of the immediate outlook for the fisheries (March 1929). Owing to the failure of the 1921 and 1922 broods more than 99 per cent. of this

stock consists of the broods from 1923 onwards. The originally plentiful 1923 brood, now in its seventh year, has ceased to be of importance. The 1924 and 1925 broods were moderate, and merely sufficed to maintain the catches about the normal for a time, now past. The more successful 1926 brood has completed its third year of life and, as was anticipated, has tended to raise the catches above normal, and should for most of its fourth year, i.e. 1929, continue to do so. By the end of this autumn, however, if we are to argue on the analogy of the fate of the 1923 brood, it will have made the major portion of its contribution. As the 1927 brood has proved to be almost a failure, catches may be expected to dwindle below the normal from late autumn until well into next year, 1930. About August of 1930 there should, on the analogy of the influence of the 1923 brood in its third year (1925) be a marked increase in the catches owing to the upgrowth of the very successful 1928 brood. In 1931 still greater catches should accrue. This is as far as can be seen ahead, for by the autumn of that year the influence of the 1928 brood will be waning and the next determining factor will be the quality (as yet unknown) of the brood of 1929.

Estimations are thus necessarily restricted to about two years ahead in the case of the southern portion of the North Sea. Corresponding but less pronounced fluctuations may be anticipated to follow a year or two later in the deeper waters to the north and west.

If these general anticipations prove correct an attempt should certainly be made to form seasonal or even monthly forecasts for the main fishing grounds.

## References.

(1) Thompson, H. General Features in the Biology of the Haddock (*Gadus aeglefinus* L.) in Icelandic Waters in the Period 1903—1926. (Rapp. et Proc. Verb. Vol. LVII. Copenhagen, 1929).

(2) Thompson H. Haddock Biology: (North Sea). A brief Survey of recent Data, Methods, and Results. (Rapp. et Proc. Verb. Vol. LIV. Copenhagen, 1929).

# VII. Note sur le Comportement du Merlu (*Merlucius merluccius* L.) pendant la première Période de Croissance.

Par

**Gérard Belloc.**

La vie du merlu comprend trois périodes de croissance que nous avons pu mettre en évidence dans notre "Note sur la croissance du Merlu".

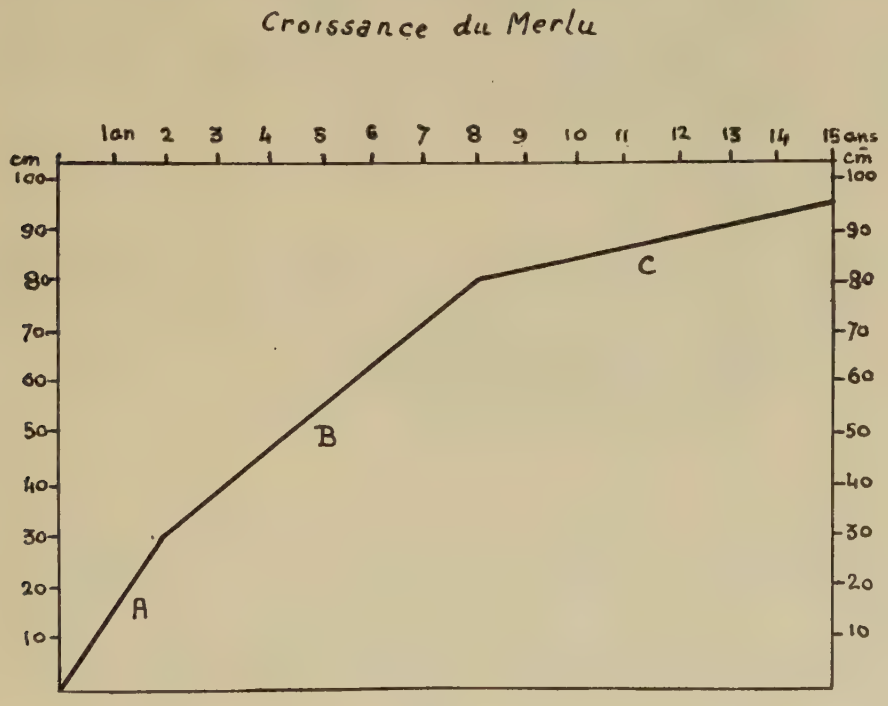



Fig. 1.

Pour étudier les fluctuations naturelles du merlu, et de tous les poissons en général, il est nécessaire de tenir compte de ces grandes divisions.

Nous les rappellerons sommairement (fig. 1):

(1) La première période de croissance (A) comprise entre l'éclosion et la première maturité sexuelle, est une période de croissance rapide. Elle dure, suivant le sexe, deux ou trois ans.

(2) La deuxième période de croissance (B) correspond à la vie sexuelle active du merlu. Pendant cette période, la croissance se trouve ralentie par l'élaboration des produits sexuels; c'est une période de croissance moyenne.

(3) La troisième période de croissance (C) est marquée par une diminution de l'activité sexuelle et de la faculté de reproduction; c'est une période de croissance lente.

Dans notre étude sur la croissance, nous avons considéré uniquement la longueur du poisson, et nous n'avons pas tenu compte du poids.

Les variations dans la longueur se produisent dans le même sens: elles sont positives. La longueur d'un poisson augmente toujours, plus ou moins, au cours de sa vie, elle ne diminue jamais en dehors des métamorphoses que certains peuvent subir pendant l'état larvaire, mais ce n'est pas le cas du merlu.

Le poids au contraire varie dans les deux sens, quelquefois même très rapidement, suivant l'état des organes génitaux et l'importance du contenu stomacal. Les variations sont tantôt positives, tantôt négatives.

Dans l'étude du comportement des jeunes merlus au cours de leur première période de croissance, les variations de poids dûes à l'état des organes génitaux sont insignifiantes, ces merlus n'ayant pas encore atteint leur première maturité sexuelle, et nous avons choisi des échantillons dont l'estomac était vide.

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Le merlu mène pendant la première partie de son existence une vie pélagique sous la forme d'œuf ou de larve; puis, lorsqu'il atteint la taille de 3 cm environ, il se rapproche du fond où il se maintiendra ordinairement pendant tout le reste de son existence.

Nous aurons donc à considérer deux stades pendant sa première période de croissance:—

(a) Le stade de la vie pélagique.
(b) Le stade de vie sur le fond.

Pendant le premier stade les œufs s'élèvent vers les couches supérieures: ils sont inertes et soumis à l'action des courants. Soixante ou 70 heures après la fécondation l'œuf éclôt; une larve d'environ 3 mm de longueur est libérée; cette larve est faible et reste soumise elle aussi à l'action des courants de surface.

Il est probable qu'à partir d'une certaine taille le jeune merlu tend à se rapprocher des côtes.

Nous avons très peu de renseignements sur ce point et les captures d'alevins sont jusqu'à ce jour peu nombreuses. Cependant si l'on en juge par la petite taille des échantillons recueillis par de faibles profondeurs, dans des chaluts à crevettes par exemple, il est permis de croire qu'à partir d'une certaine taille, avant de gagner le fond, le merlu nage activement vers la terre.

A partir du moment où le jeune merlu a gagné le fond, il se trouve dans des conditions bien différentes: les variations de température sont très faibles, et il ne se déplacerait guère s'il n'obéissait qu'à ce seul facteur. Par contre, les variations de salinité et de densité sont beaucoup plus importantes.

C'est ce qui nous a amené à étudier la composition de plusieurs lots de merlus capturés à la même époque, à des profondeurs différentes dans des régions convenablement choisies sur le plateau continental français.

Nos prélèvements d'échantillons ont été faits parmi les poissons capturés dans

Fig. 2.

une bande étroite perpendiculaire à la bordure du plateau continental suivant la direction M.N. (en août) et M'. N'. (et en mars) (fig. 2). Ce choix a été déterminé par l'utilité d'opérer sur des merlus appartenant, pour chacun des cas, à la même race locale. Le sud de l'Irlande ou l'entrée de la Manche, auraient été mal choisis, à cause de l'enchevêtrement des aires géographiques de plusieurs races locales (voir la carte).

Nous avons noté, à l'état frais, pour chacun des échantillons la taille ($L$) (longueur totale), le poids ($P$) et le volume ($V$).

## Variations de la Taille en Relation avec la Profondeur.

Les mensurations ont montré en M.N. et M'.N'., que d'une manière générale la longueur moyenne des lots capturés par des profondeurs croissantes augmentait. C'est ainsi que les merlus des 3 lots capturés en M.N. avaient une longueur moyenne:

12 cm par 70—80 mètres de profondeur.
19 cm par 100—120 mètres de profondeur.
21 cm par 150—170 mètres de profondeur.

Autrement dit dans une même race locale la taille des jeunes merlus, au cours de leur première année de croissance, augmente avec la profondeur.

Les renseignements fournis par les feuilles de pêche et l'examen des apports de jeunes merlus, concordent avec ces observations.

## Variations du $\frac{P}{V}$ en Relation avec la Profondeur.

Nous avons obtenu le volume de nos échantillons en les plongeant lentement dans un récipient préalablement rempli d'eau jusqu'au niveau d'un déversoir, et en mesurant après leur immersion, à l'aide d'une éprouvette graduée, le volume d'eau déplacé qui correspond au volume du poisson.

Ces mesures ont été faites pour chacun des lots de jeunes merlus.

Si nous désignons par $P_1$; $P_2$; $P_3$ le poids de chacun des lots capturés à des profondeurs croissantes $S_1$; $S_2$; $S_3$ etc., et par $V_1$; $V_2$; $V_3$ les volumes correspondants, nous avons pour:

$$S_1 < S_2 < S_3 \ldots\ldots\ldots$$

$$\frac{P_1}{V_1} < \frac{P_2}{V_2} < \frac{P_3}{V_3} \ldots\ldots\ldots$$

$\frac{V}{P}$ exprime la densité moyenne des poissons composant chacun des lots considérés. Ce rapport est probablement supérieur à ce qu'il serait à l'état vivant, au moment où la vessie natatoire peut fonctionner comme régulateur hydrostatique.

Quoi qu'il en soit nous avons été frappés par la constance des variations du $\frac{P}{V}$ en relation avec la profondeur et nous pouvons dire en tenant compte de la réserve faite sur la valeur du terme densité:

La densité moyenne des poissons d'une même race locale augmente avec la profondeur.

Et le jeune merlu au cours de sa première année de croissance doit rechercher pour s'y maintenir avec le minimum d'effort, des eaux de densités croissantes, autrement dit de salinité de plus en plus élevée.

Il obtiendrait ce résultat en émigrant vers la profondeur si l'ensemble des eaux de son secteur géographique était en équilibre, la salinité augmentant progressivement de la surface vers le fond. Mais cet état d'equilibre n'existe pas, il est troublé par le jeu des transgressions sur le plateau continental.

L'examen des courbes de salinité dans les couches profondes montre que pendant

les mois d'été les eaux du large plus salées et par suite plus denses que les eaux littorales avancent plus ou moins sur le plateau continental, tandis qu'elles se retirent en hiver.

En tenant compte de ces modifications des conditions de salinité le profil de la migration des jeunes merlus au cours de leur première période de croissance doit être le suivant.

Les trajets *bc* et *de* correspondent, pour une même classe annuelle de merlu aux

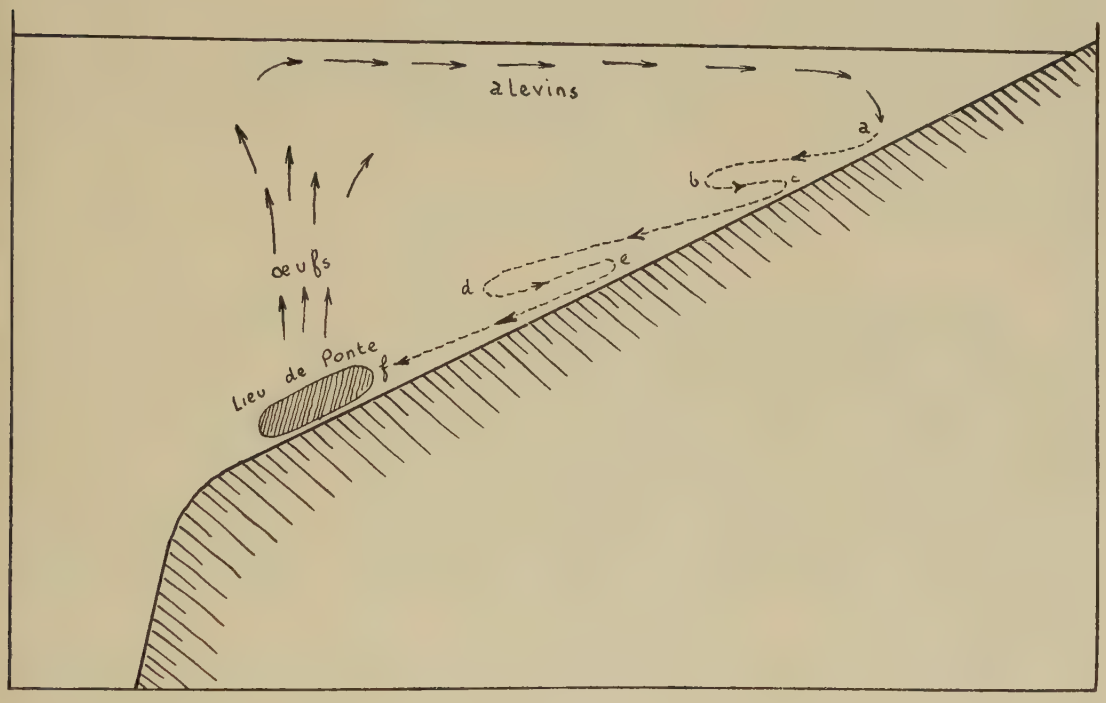


Fig. 3.

transgressions de deux années consécutives. Les trajets *ab*, *cd* et *ef* aux régressions, et leur amplitude doit être en relation avec l'amplitude du mouvement transgressif.

Les jeunes merlus, au cours de leur première période de croissance, sont ainsi amenés vers la bordure du plateau continental qui se trouve être l'habitat ordinaire des merlus adultes, qui sont entrés dans la seconde période de croissance.

Nous avons l'intention de poursuivre dans le même sens l'étude des deux autres périodes de croissance en tenant compte de l'âge et du sexe des échantillons capturés et en faisant, sur le lieu de capture, une station hydrographique complète (température, salinité, densité .....).

# VIII. Fluktuationen im Seezungenbestande der Deutschen Bucht.

Von

**A. Bückmann,** Helgoland.

Die Untersuchungen über Fluktuationen, die in anderen Gebieten so fruchtbare Ergebnisse hatten, sind in dem Gebiet der südöstlichen Nordsee von Deutscher Seite erst seit verhältnismässig kurzer Zeit aufgenommen worden. Die drei wesentlichen Gründe dafür sind die folgenden: Einmal wurde die verfügbare Arbeitskraft zum grossen Teil von anderen, langwierigen Untersuchungen in Anspruch genommen, zweitens hat sich die Erscheinung der Fluktuationen in dem genannten Areal nicht mit der Wucht geltend gemacht, die in anderen Gebieten zur Aufnahme der Untersuchungen geradezu zwang, drittens aber stellen sich der Erkennung und Analyse der Fluktuationen gerade hier jene Schwierigkeiten entgegen, die Hjort in seiner Arbeit von 1926 bereits gekennzeichnet hat.

Das Bodenrelief und die Bodenart wie auch die meisten anderen Lebensbedingungen sind in der südöstlichen Nordsee über weite Strecken hin gleichartig. Das Gebiet beherbergt infolgedessen in fast allen seinen Teilen die Entwicklungs- und Altersstadien seiner wichtigsten Nutzfische in wechselnder Durchmischung, sodass der Fang an einer begrenzten Stelle niemals als repräsentativ für den ganzen Bestand angesehen werden kann. Ist es aber schon schwierig, eine repräsentative Bestandsprobe der Alterszusammensetzung zu erhalten, (was bei zweckmässiger Wahl der Stationen immerhin möglich ist), so gilt das in noch höherem Masse von der Feststellung der Dichte des Bestandes. Diese Kenntnis ist aber unbedingt nötig, um die Häufigkeit des einzelnen Jahrgangs so zu kennzeichnen, dass sie mit der anderer Jahrgänge verglichen werden kann. In vielen Fällen hat man den Durchschnittsfang der Fischerfahrzeuge, etwa den Fang je Reisetag oder je 100 Stunden, zur Beurteilung der Bestandsdichte verwenden können. Gegenwärtig ist jedoch die Befischung der Deutschen Bucht durch deutsche Fischdampfer nicht entfernt gleichmässig und intensiv genug, um dies Verfahren zu ermöglichen. Für die Kutter aber, deren Hauptfanggebiet die Deutsche Bucht ist, ist die Angabe der aufgewendeten Befischungsstärke nicht genau genug. Leider sind auch die Voraussetzungen nicht gegeben, um Leas Methode des Sterblichkeitskoeffizienten beim Vergleich der Stärke der Jahrgänge verwenden zu können, denn

die Wahrscheinlichkeit des Gefangenwerdens ist bei den Nutzfischen unseres Gebiets auf verschiedenen Grössenstufen sehr verschieden. Es bleibt ferner die Dichtebestimmung auf Grund der Forschungsdampferfänge. Diese liefern vollkommen zuverlässige Werte aber nur, wenn ein das ganze Areal deckendes Netz von Stationen befischt wird.

Die Analyse der Ursachen der Fluktuationen ist in jedem Falle schwierig. In noch höherem Masse als bei anderen Fischen gilt das z. B. für die Scholle. In manchen anderen Fällen liegt ja ein Anzeichen dafür vor, dass die Grösse des laichenden Bestandes und der Eiproduktion keinen ausschlaggebenden Einfluss auf den Ausfall des betreffenden Jahrgangs hat. Bei der Scholle dagegen ist das nicht erwiesen. Vielmehr müssen vergleichende Untersuchungen über die Laichmenge und die Dichte der daraus entstehenden Jahrgänge eine Reihe von Jahren hindurch angestellt werden. Dabei müssen auch die Laichgebiete der südwestlichen Nordsee in ganzem Umfang mit berücksichtigt werden. Auch die Faktoren, die das Überleben der jungen Brut auf planktonischen Stadien beeinflussen können, sind in dem ganzen Gebiet zu untersuchen. Dafür sind umfangreiche Arbeiten auf See in ungünstiger Jahreszeit erforderlich.

Die bisherigen Beobachtungen über Fluktuationen bei der Seezunge in der Deutschen Bucht erweisen nun aber, dass diese Erscheinung auch in unserm Gebiet in einem Umfange auftreten kann, der eingehende Untersuchungen wünschenswert erscheinen lässt. Wahrscheinlich bieten sich auch gerade bei diesem Fisch in mancher Beziehung günstigere Bedingungen für das Studium der Fluktuationen. Günstig z. B. ist der Umstand, dass das Verbreitungsgebiet der Seezunge in gewissem Sinne beschränkt ist. In den Sommermonaten sind auf den Gründen von mehr als 40 m Tiefe und auf der Doggerbank nur ganz verschwindende Seezungenmengen zu fangen. Nur die winterliche Tiefenwanderung führt die Seezungen in jene tieferen Gebiete. Im Frühsommer (Ende April bis Juni) laichen die Seezungen, und zwar im Küstengebiet zwischen 10 und 30 m Tiefe, am stärksten zwischen 15 und 25 m. Die grossen Seezungen, den Laichbestand, finden wir also hier auf einem ziemlich eng begrenzten Gebiet. Während nun die älteren Seezungen nach dem Laichen das flache Gebiet gleich wieder verlassen, werden junge Seezungen des dritten und vierten, manchmal auch schon des zweiten Lebensjahres, also der Jungbestand, die langsam von der Küste aus nach der Tiefe zu wandern, im Herbst in der Area $A_3$ und bei Helgoland auf den Stationen unserer periodischen Untersuchungen gefangen. Die biologische Gruppe der Jungfische ist demnach zu dieser Jahreszeit, ziemlich wenig vermischt mit älteren Fischen, dem Fange leicht zugänglich. Dieser Umstand erleichtert die Kontrolle der Alterszusammensetzung und ermöglicht frühzeitiges Erkennen der Fluktuationserscheinungen.

Unsere Untersuchungen haben erst kürzlich begonnen. Seitdem Altersbestimmungen an den Schuppen der Seezungen von E. Mohr in grösserem Umfange zum ersten Male ausgeführt waren, ist Material dafür bis 1926 nur gelegentlich gesammelt worden. Erst als im genannten Jahre das Auftreten eines reichen Jahrgangs sich ankündigte, wurde mit regelmässiger Entnahme von Proben begonnen. Leider beschränken sich unsere Untersuchungen bisher auf die südöstliche Nordsee. Die Gebiete der Flämischen Bucht und der englischen Ostküste sind noch nicht mit herangezogen worden. Da es sich um sehr wichtige Seezungengebiete handelt, wäre eine Ergänzung der deutschen

Arbeiten durch andere Forscher hier sehr erwünscht. Wenige Einzelbeobachtungen und einige Bemerkungen in Gilsons kürzlich veröffentlichter Arbeit über die belgische Küstenfischerei deuten darauf hin, dass die Verhältnisse in der Flämischen Bucht ähnlich liegen wie in der Deutschen Bucht.

Betrachten wir nun die Ergebnisse der Altersbestimmungen an Seezungen, zunächst die aus den Jahren von 1925 an bei Helgoland (im Juli—August und im Sep-

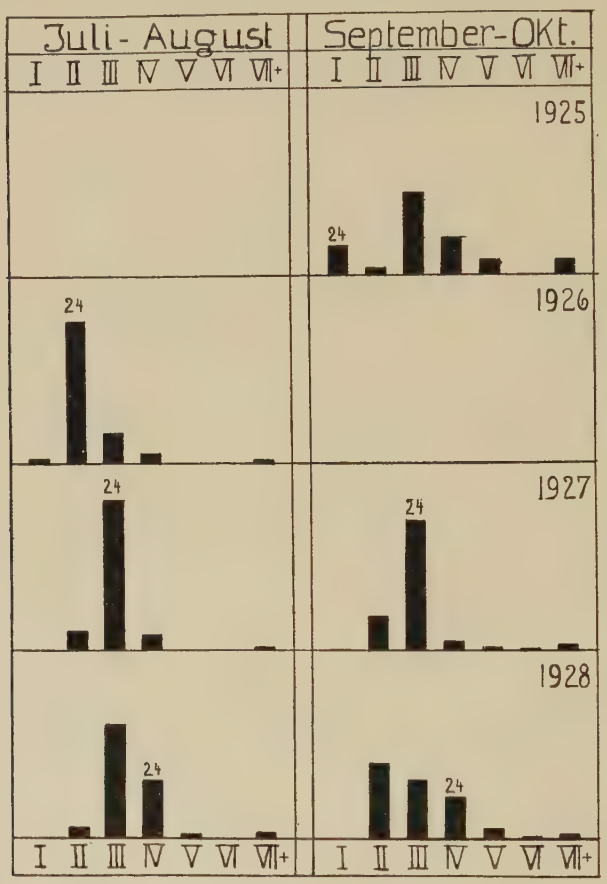


Fig. 1. Alterszusammensetzung des Seezungenbestandes bei Helgoland 1925—28.
Die Zahlen über den Säulen geben das Geburtsjahr der betr. Altersgruppe an.

tember—Oktober) und auf dem Norderneyschnitt, wie sie in Tabelle 1 zusammengefasst und in Fig. 1 u. 2 graphisch dargestellt sind. Auffallen wird die geringe Zahl von Einzelbestimmungen, die den errechneten Prozentualreihen zugrunde liegt. Man muss jedoch berücksichtigen, dass die Seezunge eben ein minder häufiger Fisch ist. Bereits im Herbst 1925 lässt sich die ungewöhnliche Häufigkeit des Jahrgangs 1924 erkennen, obwohl er erst in der I-Gruppe steht. Nur die grössten Individuen dieser Altersklasse können von den Maschen der verwendeten Kurre (8-cm-Maschen) zurückgehalten werden, selten findet man sie überhaupt auf den tieferen Gründen. Trotzdem wurden 1925 im

September bei Helgoland mehr Fische der I-Gruppe als der II-Gruppe gefangen. Freilich ist das Material von bei Helgoland gefangenen und untersuchten Seezungen klein; jedoch wird das Vorherrschen der I-Gruppe in der ganzen Deutschen Bucht durch andere Untersuchungen bestätigt (Fig. 3. Die Längenzusammensetzung der auf Alter untersuchten Seezungen der Poseidonfahrt vom September 1925 stimmt nicht ganz mit der aller gefangenen überein. Wären alle Seezungen auf Alter untersucht, so würde die I-Gruppe im Verhältnis noch stärker hervortreten).

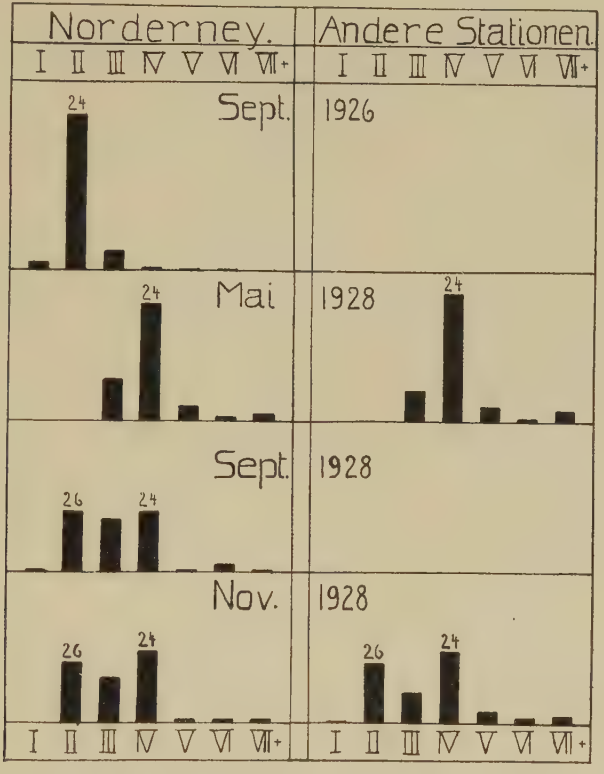


Fig. 2. Alterszusammensetzung des Seezungenbestandes auf den Stationen des Norderneyschnitts und anderen Stationen der Deutschen Bucht 1926—28.
Die Zahlen über den Säulen geben das Geburtsjahr der betr. Altersgruppe an.

Von 1926 an wird dann der wesentliche Teil des Bestandes vom Jahrgang 1924 gestellt. Er überwiegt alle anderen Altersgruppen ganz beträchtlich. Von den im September 1926 auf dem Norderneyschnitt gefangenen Seezungen gehören z. B. nicht weniger als 83 % zur II-Gruppe. Ein ähnliches Verhältnis finden wir bei Helgoland in Juli—August 1927 für die III-Gruppe, und auch im September des Jahres sind noch 70 % der Fische dreijährig. — Im September 1927 war die Untersuchung des Norderneyschnittes nicht möglich, dagegen wurde sie im Mai 1928 wieder ausgeführt. Auch hier bildet der Jahrgang bei weitem das Maximum. Die ♀ Fische befanden sich zu dieser Zeit fast ausnahmslos auf den letzten Stadien der Laich-Vorbereitung. (Bei den ♂ ist die

## Tabelle 1. Prozentuale Alterszusammensetzung des Seezungenbestandes.

| A. Helgoland, Juli—August | | | | | | | | | B. Helgoland, September—Oktober | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jahr | I | II | III | IV | V | VI | VII+ | untersuchte Zahl | I | II | III | IV | V | VI | VII+ | untersuchte Zahl | Jahr |
| 1916*) | — | 12,1 | 44,4 | 29,6 | 10,8 | 2,7 | 0,4 | 223 | | | | | | | | | 1916 |
| 1923 | 2,4 | **53,6** *1921* | 29,8 | 10,7 | 1,2 | 1,2 | 1,2 | 84 | — | **49,3** *1921* | 30,4 | 7,3 | 7,3 | 2,9 | 2,9 | 69 | 1923 |
| 1925 | .. | .. | .. | .. | .. | .. | .. | .. | **16,0** *1924* | 4,0 | 44,0 | **20,0** *1921* | 8,0 | — | 8,0 | 25 | 1925 |
| 1926 | 1,4 | **75,7** *1924* | 16,2 | 5,4 | — | — | 1,4 | 75 | .. | .. | .. | .. | .. | .. | .. | .. | 1926 |
| 1927 | — | 9,8 | **80,3** *1924* | 8,2 | — | — | 1,7 | 61 | 0,4 | 18,3 | **70,4** *1924* | 4,7 | 1,8 | 1,1 | 3,2 | 274 | 1927 |
| 1928 | — | 4,8 | 59,7 | **30,6** *1924* | 1,6 | — | 3,2 | 62 | — | **40,5** *1926* | 31,0 | **21,4** *1924* | 4,8 | 0,8 | 1,6 | 126 | 1928 |

| C. Norderneyschnitt | | | | | | | | | D. Deutsche Bucht. Sonstige Fänge | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1920 Mai-Juni | .. | .. | .. | .. | .. | .. | .. | .. | — | 1,7 | 23,1 | 7,4 | 24,0 | 16,3 | 27,3 | 121 | 1920 Mai-Juni |
| 1923 Juli | .. | .. | .. | .. | .. | .. | .. | .. | 3,1 | **39,7** *1921* | 23,2 | 20,1 | 6,2 | 3,1 | 4,6 | 194 | 1923 Juli |
| 1924 Mai | .. | .. | .. | .. | .. | .. | .. | .. | — | 1,6 | **28,6** *1921* | 18,4 | 23,2 | 13,3 | 14,9 | 225 | 1924 Mai |
| 1925 Sept. | .. | .. | .. | .. | .. | .. | .. | .. | **16,8** *1924* | 3,1 | 21,1 | **23,2** *1921* | 10,5 | 11,6 | 13,7 | 122 | 1925 Sept. |
| 1926 Sept. | 4,1 | **83,0** *1924* | 10,2 | 1,3 | 0,7 | 0,7 | — | 148 | .. | .. | .. | .. | .. | .. | .. | .. | 1926 Sept. |
| 1928 Mai | — | — | 22,8 | **62,3** *1924* | 7,9 | 2,6 | 4,4 | 114 | — | — | 16,7 | **68,2** *1924* | 7,6 | 1,5 | 6,0 | 66 | 1928 Mai |
| 1928 Sept. | 1,4 | **31,9** *1926* | 27,8 | **31,9** *1924* | 1,4 | 4,2 | 1,4 | 72 | .. | .. | .. | .. | .. | .. | .. | .. | 1928 Sept. |
| 1928 Nov. | — | **32,0** *1926* | 24,0 | **38,0** *1924* | 2,0 | 2,0 | 2,0 | 50 | 1,4 | **31,4** *1926* | 15,7 | **38,6** *1924* | 5,7 | 2,9 | 4,3 | 70 | 1928 Nov. |
| Jahr | I | II | III | IV | V | VI | VII+ | untersuchte Zahl | I | II | III | IV | V | VI | VII+ | untersuchte Zahl | Jahr |

*) Nach Mohr. Juli bis September.

Anmerkung: Die kursiv gedruckten Zahlen unter den Frequenzen geben das Geburtsjahr der betr. Altersgruppe an. Die Frequenzen der Jahrgänge 1921, 1924, 1926 sind fett gedruckt.

Feststellung der geschlechtlichen Reife bekanntlich sehr schwierig). Die Seezungen des Jahrgangs 1924 haben wahrscheinlich am Ende des vierten Lebensjahres fast alle schon gelaicht. — Der Norderneyschnitt ist späterhin noch zweimal, im September und November 1928 untersucht worden. Beidemale liegt der dichteste Wert der Altersvariation noch bei der Altersgruppe IV, dem Jahrgang 1924. Fast ebenso stark ist aber jetzt der Jahrgang 1926 vertreten. Im November befanden sich die Tiere des fünften Lebensjahres schon wieder in der Vorbereitung zum Laichgeschäft. Im Mai und November 1928 wurden Altersproben auch an einigen anderen Stellen genommen. Die Ergebnisse sind in Tabelle 1 mit aufgeführt und in der rechten Hälfte von Fig. 2 graphisch dargestellt. Die grosse Übereinstimmung mit der gleichzeitig festgestellten Alterszusammensetzung auf dem Norderneyschnitt (in Fig. 2 links) trotz des kleinen Materials erhöhen das Vertrauen darauf, dass unsere Proben bis zu einem gewissen Grade repräsentativ sind. Im Mai wurden bei Spiekeroog und vor der Hever, im November bei Westertill, Weserfeuerschiff, Amrum-Bank-Schnitt und Haaks Feuerschiff Schuppen genommen. — Wie auf dem Norderneyschnitt, so treten auch bei Helgoland jüngere Fische im Sommer und Herbst 1928 in den Vordergrund. Die Altersgruppe III und vor allen im September II (Jahrgang 1926) überwiegen über die vierjährigen Fische des Jahrgangs 1924, der also jetzt langsam aus dem Jungbestand verschwindet. Es ist jedoch wohl nicht anzunehmen, dass die Rolle des Jahrgangs 1924 schon endgültig ausgespielt ist. Vielmehr sollte man annehmen, dass er einen wesentlichen Teil des Laichbestandes der Periode 1929 bilden wird.[1])

Aus früheren Jahren haben wir nur einige vereinzelte Untersuchungen, und zwar solche von Helgoland aus den Herbstmonaten von 1916 (Bestimmungen von E. Mohr) und von 1923. Im ersteren Falle liegt das Maximum bei der III-Gruppe, also dem Jahrgang 1913, in letzterem bei Jahrgang 1921 in der II-Gruppe. (Tabelle 1 und Fig. 3). In den Jahren 1923 bis 1925 wurde bei Gelegenheit der Poseidonfahrten in der Deutschen Bucht zu verschiedenen Jahreszeiten Altersbestimmungsmaterial gesammelt. Die Ergebnisse der Untersuchung sind gleichfalls in Fig. 3 dargestellt. In allen drei Reihen liegt das Maximum auch hier beim Jahrgang 1921. Im Juli 1923 herrscht die II-Gruppe deutlich vor. Im Mai 1924 zeigt sich trotz der Laichansammlung vieler alter und grosser Fische ein leichtes Vorwiegen der dreijährigen und im September 1925 ist die IV-Gruppe etwas stärker vertreten als die nächstfolgende III-Gruppe. Aus diesen Untersuchungen ist zu entnehmen, dass auch der Jahrgang 1921 gut ausgefallen sein muss, doch erreicht er nicht entfernt die Bedeutung des Jahrgangs 1924.

Erwähnt werden mag noch eine Untersuchungsreihe aus dem Mai 1920 (Deutsche Bucht, Tabelle 1). Eine auffällige Einsenkung des Polygons bei der Altersgruppe IV

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[1]) Anmerkung: Die Laichperiode 1929 ist anscheinend durch die strenge Kälte des Winters verzögert. In der Deutschen Bucht waren Anfang Mai nur sehr wenige, an der nordfriesischen Küste praktisch keine Seezungen zu fangen. Erst späterhin scheinen sie sich dort in etwas grösserer Zahl eingefunden zu haben. Nach einigen vorläufigen Untersuchungen scheint die ausgesprochene Erwartung wenigstens insofern erfüllt worden zu sein, als von den wenigen gefangenen Seezungen ein sehr hoher Prozentsatz dem Jahrgang 1929 angehörte. Nach verschiedenen Mitteilungen ist damit zu rechnen, dass nennenswerte Mengen von Seezungen infolge der starken Auskühlung des Wassers zugrunde gegangen sind.

scheint darauf hinzudeuten, dass der Jahrgang 1916 schlecht ausgefallen war. Ferner erscheint es bemerkenswert, dass der Bestand in diesem Jahre in etwa dem gleichen Untersuchungsgebiet durchschnittlich bedeutend älter ist als im gleichen Monat des Jahres 1924, garnicht zu reden von der Zusammensetzung des Laichbestandes von Mai 1928, wie sie durch die Untersuchungen auf dem Norderneyschnitt wiedergegeben wird. Wahrscheinlich haben wir auch hier in den ersten Nachkriegsjahren einen »angehäuften Bestand« vor uns.

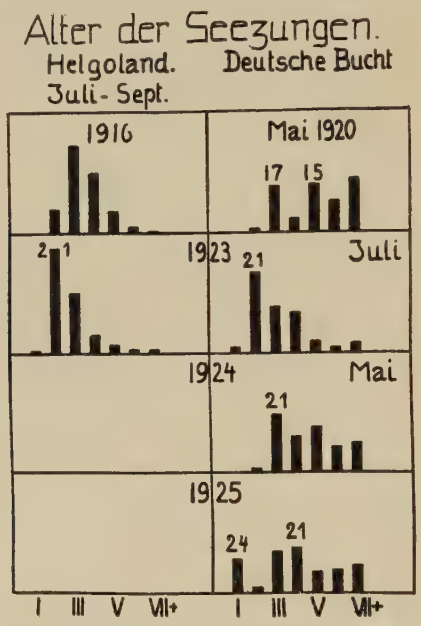


Fig. 3. Alterszusammensetzung des Seezungenbestandes bei Helgoland und auf anderen Stationen der Deutschen Bucht in früheren Jahren.
Die Zahlen über den Säulen geben das Geburtsjahr der betr. Altersgruppe an.

Damit ist das deutsche Altersbestimmungsmaterial von der Seezunge erschöpft. Einiges Interesse beansprucht jedoch noch die Längenzusammensetzung des Bestandes. Wir beschränken uns an dieser Stelle auf die Untersuchung der Längenvariation der Herbstfänge bei Helgoland, die seit 1919 in ununterbrochener Reihe mitgeteilt sind. Tabelle 2 gibt die auf 2 cm geglätteten Prozentualreihen und Fig. 4 die danach gezeichneten Polygone. In den Jahren von 1925 an ist das Heranwachsen des Jahrgangs 1924 von der I- bis zur III-Gruppe deutlich zu verfolgen. In der Figur sind die mittleren Längen der Altersgruppen II und III durch gerissene Linien angegeben (♂ + ♀). Der Unterschied zwischen der Länge der Geschlechter ist allerdings bei der III-Gruppe schon so bedeutend, dass die ungeglättete Kurve einen doppelten Gipfel aufweist. Je nach dem Vorwiegen eines Geschlechts fällt daher die Gipfelordinate neben die des Längenmittels für beide Geschlechter. — In ähnlicher Weise, aber minder deutlich lässt sich auch das Heranwachsen des Jahrgangs 1921 in den Untersuchungsreihen von 1922 bis

Tabelle 2. Seezungenmessungen bei Helgoland. Prozentualreihen, auf 2 cm geglättet.

| cm | 1919 | 1920 | 1921 | 1922 | 1923 | 1924 | 1925 | 1926 | 1927 | 1928 |
|---|---|---|---|---|---|---|---|---|---|---|
| 12 | 1,5 | 0,6 | .. | .. | .. | .. | .. | .. | .. | .. |
| 14 | 2,6 | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| 16 | 13,9 | 0,2 | 0,5 | .. | .. | .. | 3,9 | 0,7 | 0,4 | .. |
| 18 | 11,3 | 1,1 | 0,5 | 4,9 | .. | .. | 5,9 | 2,0 | .. | .. |
| 20 | 1,0 | 1,5 | .. | 5,4 | 8,5 | .. | 15,7 | 5,6 | 0,7 | .. |
| 22 | 3,6 | 27,6 | .. | 7,6 | 22,2 | 2,2 | .. | 34,0 | 1,8 | 12,3 |
| 24 | 15,9 | 36,5 | 4,7 | 24,2 | 12,4 | 13,0 | 9,8 | 37,6 | 13,5 | 31,0 |
| 26 | 18,5 | 13,0 | 14,6 | 30,5 | 20,9 | 17,4 | 15,7 | 10,5 | 17,5 | 18,7 |
| 28 | 3,6 | 6,5 | 25,0 | 7,6 | 9,2 | 28,3 | 17,6 | 2,7 | 24,5 | 20,0 |
| 30 | 0,5 | 5,2 | 16,2 | 6,3 | 10,4 | 19,4 | 9,8 | 2,0 | 27,4 | 8,4 |
| 32 | 2,1 | 3,9 | 10,9 | 6,3 | 5,2 | 4,5 | 7,9 | 1,3 | 7,7 | 3,9 |
| 34 | 3,6 | 1,1 | 7,3 | 4,5 | 2,6 | 6,5 | 5,9 | 0,7 | 1,8 | 4,5 |
| 36 | 6,2 | 0,4 | 5,0 | 0,9 | 3,9 | 4,5 | 2,0 | 1,3 | 1,5 | .. |
| 38 | 6,2 | 1,1 | 3,6 | 1,8 | 2,6 | 2,2 | 2,0 | 1,0 | 0,7 | .. |
| 40 | 3,6 | 0,4 | 6,8 | .. | 1,3 | 2,2 | 2,0 | 0,7 | 1,1 | 0,6 |
| 42 | 2,6 | 0,2 | 3,1 | .. | 0,6 | .. | .. | .. | 1,5 | .. |
| 44 | 2,6 | 0,7 | 1,0 | .. | .. | .. | 2,0 | .. | .. | 0,6 |
| 46 | .. | .. | 0,5 | .. | .. | .. | .. | .. | .. | .. |
| 48 | 0,5 | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| 50 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| Zus.... | 194 | 463 | 192 | 223 | 153 | 46 | 51 | 303 | 274 | 155 |
| Fangmonate | IX/X | IX | VII | X | VIII/IX | IX | X | IX | X | IX/X |

1924 erkennen. (Der doppelte Gipfel im Jahre 1923 ist darauf zurückzuführen, dass einige Fänge von August berücksichtigt werden mussten, da das Material sonst zu klein gewesen wäre). Eine sehr ähnliche Erscheinung findet sich wieder in den Jahren 1919 bis 1921. Wenn wir in diesen Jahren die gleiche Wachstumsgeschwindigkeit voraussetzen dürfen, wie wir sie gegenwärtig beobachten, so muss es sich in diesem Falle um das Heranwachsen des Jahrgangs 1918 gehandelt haben. (In der Tat ist ein klarer Unterschied in der mittleren Länge gleich alter Seezungen aus den Untersuchungen von E. Mohr von 1916 und denen der letzten Jahre nicht festzustellen. Das Material ist ja allerdings auch nicht besonders gross).

Was die absolute Häufigkeit der Jahrgänge betrifft, so kann sie durch den Durchschnittsfang je Stunde unserer Forschungsfahrzeuge charakterisiert werden. Dabei ist zu berücksichtigen, dass die Zahl der vergleichbaren Fänge sehr gering ist, zu gering, um bei der grossen Zahl unkontrollierbarer Faktoren, die die Fangmenge beeinflussen, sichere Schlüsse darauf zu gründen. In früheren Jahren sind zudem nicht alle Seezungenfänge auf Alter untersucht worden, sodass es nicht möglich ist, die Fangdichte der einzelnen Jahrgänge zu vergleichen. Immerhin aber sehen wir doch in guter Übereinstimmung mit den theoretischen Erwartungen gleichzeitig mit dem Auftreten des Jahrgangs 1924 ein plötzliches Anschwellen des gesamten Durchschnittsfanges. Tabelle 3 und Fig. 5 zeigen das vergleichbare Material: Es sind die beiden Helgoländer Untersuchungsreihen von Juli—August und September—Oktober aus den Jahren

1922—1928 und die Fänge vom Norderneyschnitt aus dem Mai der Jahre 1925, 1927, 1928 (Motorschiff Augusta) und aus dem September 1925, 1926, 1928 (Reichsforschungsdampfer Poseidon). Bei Helgoland zeigt sich im Juli 1926, als der Jahrgang 1924 in der II-Gruppe stand, eine gewaltige Steigerung des Stundenfanges gegenüber den Vorjahren.

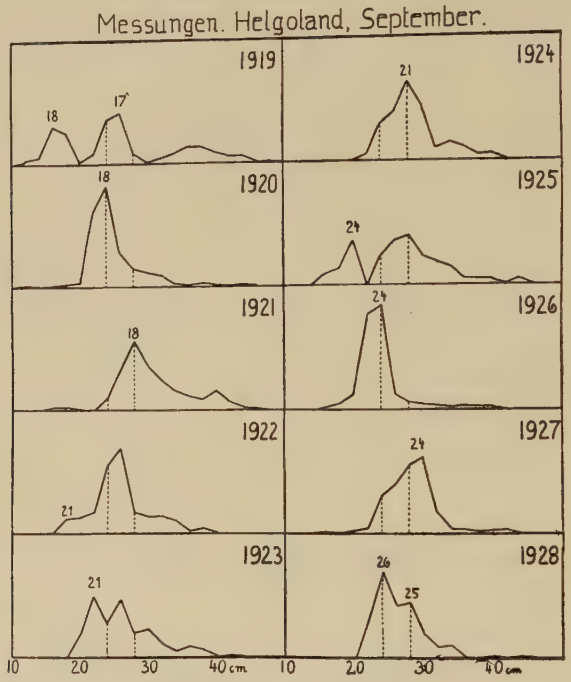


Fig. 4. Längenzusammensetzung des Seezungenbestandes bei Helgoland im Herbst. Auf 2 cm geglättete Prozentualpolygone.
Die Zahlen über den Polygonen geben die Jahrgänge an, die im Mittel die betr. Länge haben. Mittlere Länge der Altersgruppen II und III durch gerissene Ordinaten bezeichnet.

Tabelle 3. Deutsche Forschungsfahrzeuge. Stundenfang an Seezungen. (Stück pro Fangstunde).

| | 1922 | 1923 | 1924 | 1925 | 1926 | 1927 | 1928 |
|---|---|---|---|---|---|---|---|
| Bei Helgoland, Juli—August: (Zungenkurre d. „Augusta") | 4,2 | 17,0 | 2,8 | 1,1 | 41,0 | 12,3 | 11,5 |
| Bei Helgoland, Sept.—Okt.: (Zungenkurre d. „Augusta") | 10,5 | 12,7 | 9,9 | — | 37,0 | 44,3 | 17,4 |
| Auf dem Norderneyschnitt, Mai: (Zungenkurre d. „Augusta") | - | — | — | 5,8 | – | 12,6 | 25,0 |
| Auf dem Norderneyschnitt, Sept.: (Gr. Kurre des „Poseidon") | — | — | — | 4,3 | 64,3 | — | 12,0 |

Anmerkung. Ein — bedeutet, dass mit dem betr. Gerät kein Fang gemacht wurde.

Die nächstgrosse Fangdichte ist 1923 beobachtet, als die II-Gruppe von dem guten Jahrgang 1921 gebildet wurde. Die Fänge von 1927 und 1928 sind etwas kleiner. Es ist nicht unmöglich, dass das 1927 nur darauf zurückzuführen war, dass die Juliuntersuchungen ziemlich früh im Monat stattfanden, denn in der Septemberreihe ist der Fang in diesem Jahre ausserordentlich gross, sogar grösser als 1926. Im Jahre 1928 ist auch hier mit dem Zurücktreten des Jahrgangs 1924 in dem Jungbestand ein bedeutender

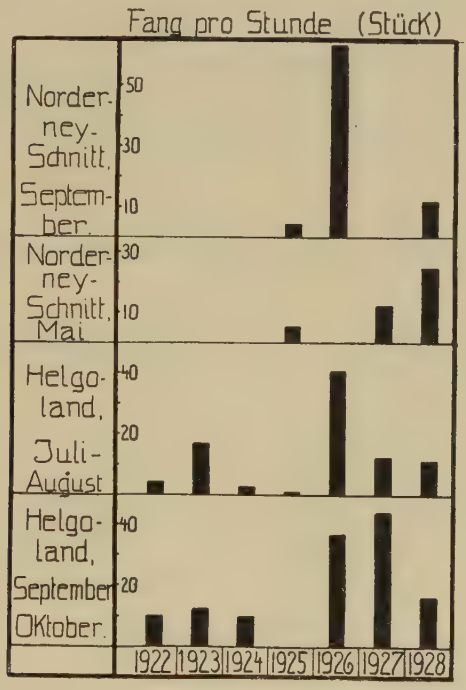


Fig. 5. Durchschnittsfang deutscher Forschungsfahrzeuge an Seezungen.
Die 1. Serie mit der grossen Kurre des „Poseidon", die drei andern mit der Zungenkurre der „Augusta".

Rückgang zu sehen, doch übertreffen die Fänge dieses Jahres noch alle vor 1926 gelegenen, auch die des Jahres 1923.

Auf dem Norderneyschnitt fällt bei der Septemberreihe das gewaltige Ansteigen des Fanges 1926 gegenüber dem vorhergehenden Jahre auf, 1927 fehlen leider Untersuchungen, 1928 sind die Fänge auch hier wieder bedeutend geringer, wohl infolge des Abwanderns der grösseren Seezungen des Jahrgangs 1924, die zumeist in diesem Jahre schon gelaicht hatten. Im Mai, wo auf dem Norderneyschnitt die laichenden Seezungen gefangen werden, macht sich die Zunahme der Fangdichte 1927 im Vergleich zu 1925 noch wenig, im Mai 1928 dagegen ganz deutlich bemerkbar. Wie gesagt, kann die Dichte der einzelnen Jahrgänge aus diesem spärlichen Material noch nicht mit irgend einem Anspruch auf Zuverlässigkeit berechnet werden. Die wahrscheinlichsten Werte, die sich ergeben, besagen, dass der Jahrgang 1924 vielleicht 8 mal so gut wie andere Jahrgänge und etwa 3 mal so gut wie der Jahrgang 1921 gewesen sein muss. Der Jahrgang 1926

Tabelle 4. Seezungenfang deutscher Fischdampfer je Reisetag.

Nach Marktsorten und insgesamt.

A. Area $C_2$ M.

| | Januar—April | | | | | Mai—August | | | | | September—Dezember | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I | II | III | zus. | Reise-tage | I | II | III | zus. | Reise-tage | I | II | III | zus. | Reise-tage |
| 1924 | 7,6 | 3,3 | 0,1 | 11,0 | 261 | 4,7 | 1,7 | 0,8 | 7,2 | 389 | 4,5 | 3,3 | 0,3 | 8,1 | 428 |
| 1925 | 8,6 | 5,5 | 1,6 | 15,7 | 848 | 0,6 | 0,2 | 0,2 | 1,0 | 612 | 5,6 | 2,3 | 0,2 | 8,1 | 1071 |
| 1926 | 6,8 | 2,7 | 0,5 | 10,0 | 738 | 0,3 | 0,1 | 0,02 | 0,4 | 782 | 5,3 | 3,1 | **4,3** | 12,7 | 947 |
| 1927 | 7,5 | 3,4 | 3,2 | 14,2 | 359 | 0,5 | 0,3 | 0,1 | 0,9 | 591 | 4,0 | **4,6** | **2,3** | 10,9 | 722 |
| 1928 | 4,4 | 2,9 | 1,1 | 8,4 | 195 | 0,2 | 0,1 | 0,1 | 0,4 | 431 | 1,9 | 1,5 | 1,0 | 4,4 | 391 |

B. Area $B_4$.

| | Januar—April | | | | | Mai—August | | | | | September—Dezember | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I | II | III | zus. | Reise-tage | I | II | III | zus. | Reise-tage | I | II | III | zus. | Reise-tage |
| 1924 | 5,3 | 2,9 | 0,6 | 8,8 | 511 | 32,7 | 14,0 | 5,3 | 51,9 | 1064 | 9,6 | 5,5 | 2,0 | 17,1 | 402 |
| 1925 | 21,1 | 10,1 | 3,5 | 34,7 | 318 | 12,6 | 12,1 | 6,1 | 30,8 | 400 | 7,1 | 1,6 | 0,4 | 9,1 | 239 |
| 1926 | 22,2 | 10,2 | 2,1 | 34,5 | 337 | 5,2 | 2,8 | 0,5 | 8,5 | 179 | 9,3 | 6,2 | **8,4** | 23,9 | 172 |
| 1927 | 5,1 | 2,2 | 2,9 | 10,2 | 397 | 1,3 | 1,6 | 3,0 | 5,9 | 135 | 14,6 | **14,5** | **9,5** | 38,5 | 260 |
| 1928 | 3,0 | 1,7 | 0,7 | 5,4 | 379 | **10,8** | **19,4** | 5,9 | 36,1 | 221 | 1,9 | 2,7 | 3,9 | 8,4 | 86 |

C. Area $A_3$. März—Juli.

| | I | II | III | zus. | Reise-tage |
|---|---|---|---|---|---|
| 1924..... | 44,3 | 33,3 | 7,6 | 85,1 | 177 |
| 1925..... | 15,4 | 8,9 | 1,2 | 25,5 | 44 |
| 1926..... | 8,5 | 1,8 | 0,1 | 10,4 | 150 |
| 1927..... | — | — | — | — | — |
| 1928..... | 89,5 | 78,5 | 27,6 | 195,6 | 89 |

scheint auch über den Durchschnitt hervorzuragen. Er kommt vielleicht dem Jahrgang 1921 etwa gleich.

Vor dem Jahre 1929 sind keine Messungen und Altersbestimmungen an Marktmaterial von Seezungen ausgeführt worden. Daher können die statistischen Angaben bisher auch noch nicht zur Kennzeichnung der Fangdichte einzelner Jahrgänge benutzt werden, wie es künftig möglich sein wird. Es ist jedoch von grossem Interesse zu sehen, dass der Durchschnittsfang der Deutschen Fischerfahrzeuge gleichfalls eine erhebliche Steigerung mit dem Auftreten des guten Jahrgangs 1924 erkennen lässt. Was die Fisch-

dampfer betrifft, so fischen sie, wie erwähnt, nur wenig und unregelmässig in der Deutschen Bucht. Mehr der Vollständigkeit halber sind in Tabelle 4 die Durchschnittsfänge in den Statistischen Arealen $C_2M$ und $B_4$ für drei Gruppen von je 4 Monaten (I—IV, V—VIII, IX—XII) und für die Jahre 1924—1928 zusammengestellt und in Fig. 6 z. T. graphisch dargestellt. Die Marktsorten sind dabei unterschieden, die Sorte Klein ist durch schwarze Felder, Mittel durch gestreifte Felder, Gross durch weisse Felder dargestellt. In den Jahren 1924 und 1925 ist der Fang von kleinen Seezungen sehr gering. Im Herbst 1926 steigt

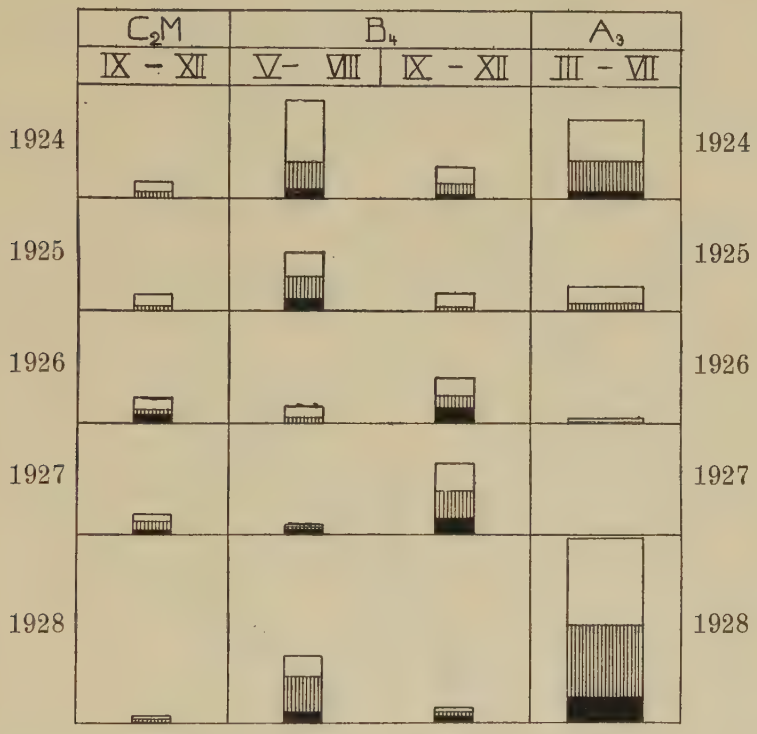


Fig. 6. Durchschnittsfang deutscher Fischdampfer an Seezungen in gewissen Gebieten und zu gewissen Jahreszeiten. Fang in Pfund je Reisetag.
Marktsorte I — Gross — weisse Felder; II — Mittel — gestreifte Felder; III — Klein — schwarze Felder. Die römischen Zahlen bezeichnen die Monate.

der Fang dieser Sorte gleichzeitig in $C_2M$ und $B_4$ an, sehr wahrscheinlich infolge der winterlichen Tiefenwanderung der kleinen Fische des Jahrganges 1924. Auch in den ersten 4 Monaten des Jahres 1927 sehen wir verhältnismässig grosse Fänge kleiner Seezungen, das gleiche gilt für $B_4$ in den Frühsommermonaten, während in $C_2M$ zu dieser Jahreszeit fast keine Seezungen mehr gefangen werden können. In den letzten Monaten des Jahres 1927 hat die Zunahme bereits auf die Marktsorte Mittel übergegriffen und ist nun ganz unverkennbar. Das stimmt gut damit überein, dass die Fische des Jahrgangs 1924 jetzt schon um 28 cm lang, die grössten schon über 30 cm sind. Im Jahre 1928 macht sich die Vergrösserung des Durchschnittsfanges hauptsächlich zur Laich-

zeit (Frühsommer) nahe der Küste ($B_4$) bemerklich, am meisten bei der Marktsorte Mittel. Die guten Fänge des Jahres 1924 sind allerdings noch nicht wieder erreicht, da viel weniger Grosse gefangen sind. In der Area $A_3$ wird von deutschen Fischdampfern wenig, in manchen Jahren garnicht, und fast stets nur in den Frühlingsmonaten (III—VI) während des Laichens der Edelfische und der Anhäufung der Schollen in diesem Gebiet gefischt. Der Durchschnittsfang an Seezungen ist in der Laichzeit hier viel grösser als in den anderen Arealen. In Fig. 6 ist daher der Fläche hier die doppelte

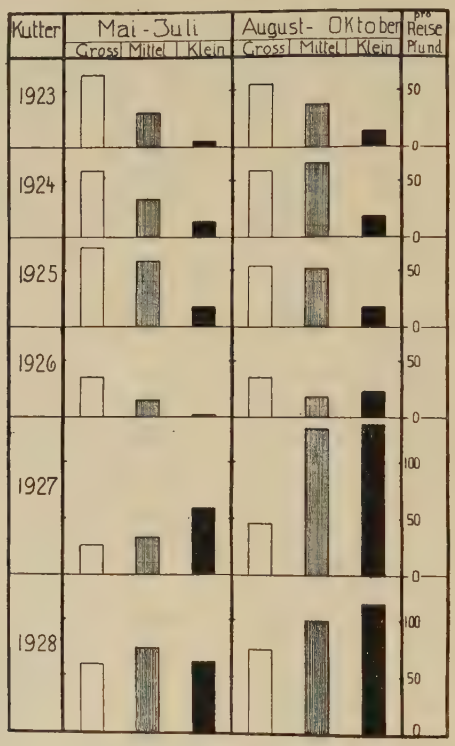


Fig. 7. Durchschnittsfang je Reise in Pfund deutscher Motorkutter mit Grundschleppnetz (Südöstliche Nordsee).
Marktsorte I — Gross — weisse Felder; II — Mittel — gestreifte Felder; III — Klein — schwarze Felder.

Breite gegeben worden. In diesem Gebiet überragt nun der Durchschnittsfang des Jahres 1928, wo die meisten Fische unseres Jahrgangs wahrscheinlich zum ersten Male laichreif wurden, alle anderen, selbst den von 1924, um ein Beträchtliches.

Bei den Fängen der deutschen Motorkutter wird z. Zt. die Zahl der Reisetage nicht angegeben, sodass nur der Fang je Reise berechnet werden kann. Die Zahl der Reisen ist natürlich an sich ein schlechtes Mass für die aufgewendete Befischungsintensität, denn der Kutter bleibt so lange in See, bis er „seine Reise hat", wenn nicht besondere Umstände zu früherer Heimkehr zwingen. So ist die Dauer der Reise von der Fangmenge und der Marktlage abhängig. Vielleicht ist aber der Fehler bei der Benutzung der Reisezahl als Mass der Befischungsintensität für die Seezunge nicht so gross wie

Tabelle 5. Seezungenfang deutscher Motorkutter pro Reise in Pfund nach Marktsorten getrennt und insgesamt.

| | Mai—Juli | | | | | August—Oktober | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | I | II | III | zus. | Zahl d. Reisen | I | II | III | zus. | Zahl d. Reisen |
| 1923..... | 65 | 31 | 5 | 101 | 352 | 56 | 38 | 14 | 108 | 256 |
| 1924..... | 59 | 34 | 14 | 108 | 564 | 59 | 66 | 19 | 144 | 536 |
| 1925..... | 71 | 59 | 18 | 148 | 665 | 54 | 52 | 18 | 124 | 466 |
| 1926..... | 35 | 15 | 2 | 52 | 555 | 35 | 18 | **23** | 76 | 513 |
| 1927..... | 26 | **33** | **59** | 118 | 673 | 46 | **130** | **134** | 310 | 569 |
| 1928..... | **60** | **75** | **63** | 198 | 780 | **74** | **100** | **115** | 229 | 742 |

z. B. für die Scholle, die als eigentlicher Massenfisch den Hauptfang der Kutter ausmacht. Die Seezunge ist zwar ein wertvoller und sehr begehrter Beifang, doch richtet sich die Reisedauer der Kutter wahrscheinlich nur wenig nach dem Fangertrag dieses Fisches. Hier sind daher auch die Kutterfänge berücksichtigt worden, zumal die Befischung des Gebiets durch Kutter stark und gleichmässig ist. Der Durchschnittsfang je Reise ist für zwei Gruppen von je 3 Monaten, Mai—Juli und August—Oktober zusammengefasst worden, da ausserhalb dieser Zeit von Kuttern so gut wie gar keine Seezungen angebracht werden (Fig. 7 und Tabelle 5). Die Darstellung, wiederum nach Marktsorten gegliedert, zeigt die allmähliche Abnahme der Fänge von 1924 bis 1926. Im Herbst dieses Jahres zeigt sich zuerst eine geringe Steigerung des Fanges bei der Marktsorte Klein. Die kleinen Fische des Jahrgangs 1924 konnten seinerzeit, wie festgestellt worden ist, am Markt nur schlecht abgesetzt werden und wurden daher zumeist nicht mitgenommen. Im Jahre 1927 ist dann plötzlich die Marktsorte Klein die stärkste, während in den früheren Jahren die Grossen vorherrschten, und gleichzeitig nimmt die Fangmenge gewaltig zu. Im Herbst 1927 greift die Vermehrung des Fanges auf die Marktsorte Mittel über. Auch 1928 sind sehr grosse Fänge gemacht. Die grössten Individuen des Jahrgangs sind anscheinend schon zur Marktsorte I gerechnet worden, denn auch der Durchschnittsfang derselben nimmt nun zu[1]). Für den guten Fang kleiner Seezungen im Herbst 1928 ist vielleicht neben dem Jahrgang 1924 auch der Jahrgang 1926 und 1925 verantwortlich zu machen.

In entsprechender Weise hat auch der Gesamtertrag des Seezungenfanges seit 1927 ganz bedeutend zugenommen. Die deutschen Kutter (Tabelle 6, Fig. 8) fingen im Mittel der Jahre 1922—1926 pro Jahr etwa 60 t. Im Jahre 1927 steigt der Fang auf 130 t, 1928 auf 200 t. Von der Gesamtmenge der in der Nordsee von deutschen Fischern gefangenen und gelandeten Seezungen fingen die Kutter in den letzten Jahren etwa drei Viertel. Die Fischdampfer, die ihr Arbeitsgebiet mehr und mehr aus der südlichen

[1]) Nach Marktmessungen in Wesermünde beginnt, wie mir Dr. Lundbeck brieflich mitteilt, die Längenvariation der Sorte I schon bei 31 cm.

Nordsee herausverlegen und seit 1926 auch in dem südlichen Teil von $C_2$, wo im Winter viel Seezungen gefangen werden, nicht mehr gefischt haben, haben an dieser Zunahme keinen Anteil.

Wir haben so alle Elemente einer Fluktuationserscheinung bei der Seezunge beobachten können: die Steigerung des Fangertrages und der Fangdichte, sowohl in dem Durchschnittsfang der Fischerfahrzeuge als auch in dem der Forschungsfahrzeuge. Als Ursache dieser Vermehrung ist das massenhafte Auftreten eines Jahrgangs zu er-

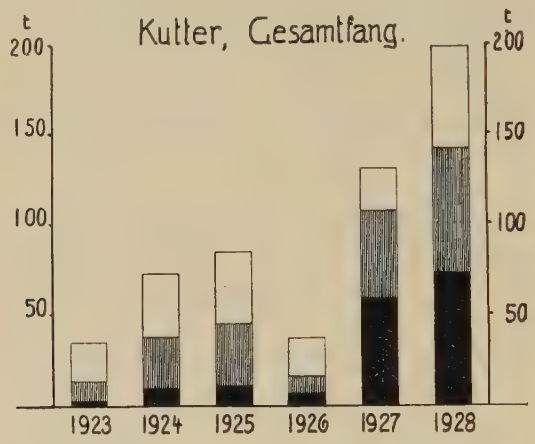


Fig. 8. Gesamtfang deutscher Motorkutter mit Grundschleppnetz. (Südöstliche Nordsee).
Marktsorte I — Gross — weisse Felder; II — Mittel — gestreifte Felder; III — Klein — schwarze Felder.

kennen, der durch mehrere Jahre hindurch den wesentlichen Teil des Bestandes bildet, und der sich von frühen Stadien an als besonders reich verglichen mit den benachbarten Jahrgängen zeigt.

Tabelle 6. Gesamt-Seezungenfang deutscher Motorkutter in 1000 kg.

| Jahr | I | II | III | Zus. |
|---|---|---|---|---|
| 1923 | 22 | 11 | 3 | 35 |
| 1924 | 35 | 29 | 9 | 73 |
| 1925 | 41 | 34 | 11 | 86 |
| 1926 | 21 | 10 | 7 | 37 |
| 1927 | 23 | **49** | **58** | 131 |
| 1928 | **57** | **69** | **72** | 198 |

Unsere Untersuchungen stehen noch im Anfang; es hat sich aber herausgestellt, dass gewisse Bedingungen trotz der schwierigen Verhältnisse in der südöstlichen Nordsee der Analyse der Fluktuationen bei der Seezunge günstig sind. Es scheint verhältnismässig leicht zu sein, repräsentative Proben des Laichbestandes im Frühling und des Jungbestandes im Herbst zu gewinnen. Auch scheinen die Fangdichtebestimmungen nicht allzu schwierig zu sein, zumal wenn die Befunde der Forschungsfahrzeuge bestätigt werden durch eine Kombination von Marktstatistik und Altersuntersuchungen

an Marktmaterial. Letztere sind im Jahre 1929 in bescheidenem Umfange bereits in Angriff genommen.

Auch die Analyse der Ursachen des verschiedenen Ausfalls der Jahrgänge findet verhältnismässig günstige Vorbedingungen in der besseren Wetterlage zur Laichzeit und der Nähe der Laichplätze. Ferner ist das Ei der Seezunge verhältnismässig leicht und sicher zu erkennen. Die Ausdehnung der Untersuchungen auf die anderen wichtigen Seezungengebiete der Nordsee ist dringend erwünscht.

## Résumé.

In the autumn of 1926 there were suddenly caught off Heligoland an unusual quantity of small common soles (*Solea vulgaris*) only a little over 20 cm. in length. Age-determinations (Tab. 1), which had hitherto been carried out only intermittently, were thenceforward undertaken systematically, and confirmation was obtained of the conjecture that it was a question here of the brood of a single good year-class, viz.: of the 1924 year-class (Fig. 1, 2). In the autumn of the years 1926 and 1927 this constituted off Heligoland and in the Norderney Gap the main part of the stock (up to 4/5ths), and was present as a I-group in remarkable numbers as early as the autumn of 1925, although only a small fraction of these young fish were retained by the meshes of our trawl. In May 1928 common soles of this year-class in a condition ready for spawning were taken in relatively large numbers in shallow water in the Norderney Gap. In September and November, 1928, also, it again constituted the maximum, but was almost caught up by the younger groups (especially the II-group), and even ceded first place to the latter off Heligoland (July—October), since, apparently, apart from the spawning season, the older common soles are found further off-shore than the younger. From the intermittent earlier age-determinations it is evident that the 1921 year-class is also of great relative frequency, even though to a far smaller extent than the 1924 class (Fig. 3).

The appearance and development of these two year-classes is clearly shown in the comparison of length of the autumn catch off Heligoland. From the series of measurements of the years 1919 to 1921 it may be seen that similarly a good year-class, probably 1918, also preponderated then (Fig. 4, Tab. 2).

It can be demonstrated for the year-class 1924 that its absolute frequency was unusually great. With its appearance the catch per hour of our research vessels rises abruptly to many times the normal (off Heligoland to 4—6 times the average of the four previous years, in the Norderney Gap in September, 1926, to fifteen times that of 1925, Fig. 5, Tab. 3).

The influence of this phenomenon of fluctuation on the takings of the German fishermen is also plain, especially of the cutters, which at the present time are responsible for more than three-quarters of the German landings of common sole from the North Sea. The total catch of this fish (Fig. 8, Tab. 6) rose from about 60 tons, the mean of the years 1923—26, to 130 tons in 1927, when the 1924 year-class reached a marketable size, and to 200 tons in 1928. Unfortunately the statistics do not furnish any exact

information as to the intensity with which the fishery was prosecuted beyond the number of trips. The duration of the individual trips can, however, be reckoned on a rough average as equal. The catch per trip was then calculated (Fig. 7, Tab. 5), and there, too, an increase is shown, small and in the autumn of 1926 and the early summer of 1927 confined to the market category "small", very considerable in the "small" and "medium" categories from the autumn of 1927 till the autumn of 1928. At that time younger year-classes also were probably intermixed with the mass of small common soles, as deduced from the age-determinations. German steam-trawlers carry on but little and irregular fishery in the most important catching area for common soles, yet the increase of the catch of small and medium common soles per trip-day in B 4 and C 2 M in the autumn of 1926 and 1927 was unmistakable (Fig. 6, Tab. 4). In the early summer of 1928, when, as mentioned, the 1924 year-class appears off the coast for the first time for spawning, in B 4 good and in A 3 quite exceptional catches of common sole per trip-day have to be recorded.

There are then to be found with the common sole fluctuations in the strength of the year-classes to an extent that decisively influences the yield of the fishery. The causes of the fluctuations can naturally not be discussed on the basis of these scanty observations. But first must be decided the essential question, whether the production of spawn or the diminution in youthful stages is the decisive factor in the case of the flat fish. It is a matter of great urgency that the quantity of eggs of the common sole be investigated through a series of years, according to Hensen's method in the excellent form elaborated by Buchanan-Wollaston and its correlation to the frequency of the respective year-classes as II- and III-groups be tested. According to the incidence of the spawning season and the situation of the spawning localities and in consequence of the ease with which the eggs can be recognised, in the case of the common sole, specially favourable conditions perhaps, present themselves for the analysis of the causes of the fluctuations.

# IX. Fluctuations in the Age-Composition of the Plaice Stock in the Southern North Sea during the Period 1923 to 1928.

By

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The detailed study of fluctuations in the age-composition of the stock of plaice has been carried out since 1926 by the Ministry of Agriculture and Fisheries. In that year, when carrying out the routine age and growth estimations, it was obvious that one year-class, that is to say the plaice spawned in 1922, predominated to a remarkable extent in the catches, while, at the same time, those spawned in 1923 were scarce, particularly in the areas south of Heligoland. In order to find out whether such fluctuations are of common occurrence, and also whether they are of sufficient magnitude to affect the commercial landings of plaice, further work has been undertaken and previous samples examined. The otolith material now available for such investigations has been collected as follows:—

1) Trawling by the Ministry's research vessel "George Bligh", using the commercial otter trawl covered with shrimp net, has been carried out along a continuous line from the Leman ground to the Haaks Light vessel in May of each year from 1923 to 1928. This line was chosen for the reason that it lies along the path of migration offshore from the Dutch coast in the spring.

   In 1928 this line of trawling was repeated in September. It was also attempted in September 1927, but owing to strong gales, trawling had to be abandoned before the most inshore station was reached and therefore the material obtained is not comparable with that of 1928.

2) Trawling investigations were carried out by the "George Bligh" near Horn Reef, in Graa Dyb and near Heligoland in June 1926 and also near Horn Reef, in Graa Dyb, near Sylt, near Heligoland, near Schiermonnikoog and off the western Dutch coast in November of the same year. Approximately the same areas were trawled in June and November 1927 and 1928. Unfortunately owing to adverse weather conditions, the catch of plaice was so small in both the 1927 cruises that it was insufficient for reliable conclusions. In 1928, however, conditions were favourable and adequate samples were obtained.

The gear used was the ordinary otter trawl; in some cases a cover net was used, but for comparable purposes the plaice retained in the cover are omitted from the discussion of results.

3) In order to test the effect of any fluctuations on the landings of plaice on the market, samples of each trade category recognised at Lowestoft were obtained from the commercial landings and were otolithed, weighed and measured in October 1926, December 1927, and December 1928. These samples were raised to the total landings and catch per 100 hours' fishing of the port for the months in which samples were taken.

### 1) Leman-Haaks Line.

The results of the investigations along the Leman-Haaks line in May are given in Table 1 and illustrated by histograms in Fig. 1.

Table 1. Catch per hour and Proportion per cent. of each Age-group of Plaice taken from the Leman ground to the Haaks Light Vessel in May of the Years 1923—1928.

| | Age-groups | | | | | | | | No. of Otoliths examined |
|---|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI | VII | VIII+ | |
| Year | | | | | | | | | |
| 1923. Catch per hour | 0.3 | 48.6 | 81.3 | 42.5 | 7.6 | 2.2 | 0.8 | 0.0 | |
| Proportion per cent. | 0.1 | 26.5 | 44.4 | 23.2 | 4.2 | 1.2 | 0.4 | 0.0 | 1820 |
| Year of Birth | 1922 | 1921 | 1920 | 1919 | 1918 | 1917 | 1916 | 1915— | |
| 1924. Catch per hour | 0.6 | 27.3 | 62.0 | 27.8 | 11.5 | 1.5 | 0.4 | 0.4 | |
| Proportion per cent. | 0.4 | 20.8 | 47.1 | 21.2 | 8.7 | 1.2 | 0.3 | 0.3 | 4160 |
| Year of Birth | 1923 | 1922 | 1921 | 1920 | 1919 | 1918 | 1917 | 1916— | |
| 1925. Catch per hour | 0.5 | 8.5 | 72.3 | 73.1 | 29.9 | 7.0 | 0.7 | 0.4 | |
| Proportion per cent. | 0.2 | 4.4 | 37.6 | 38.0 | 15.6 | 3.6 | 0.4 | 0.2 | 5451 |
| Year of Birth | 1924 | 1923 | 1922 | 1921 | 1920 | 1919 | 1918 | 1917— | |
| 1926. Catch per hour | 6.4 | 20.2 | 18.2 | 50.1 | 20.5 | 5.1 | 0.8 | 0.1 | |
| Proportion per cent. | 5.2 | 16.7 | 15.0 | 41.3 | 16.8 | 4.2 | 0.7 | 0.1 | 3515 |
| Year of Birth | 1925 | 1924 | 1923 | 1922 | 1921 | 1920 | 1919 | 1918— | |
| 1927. Catch per hour | 6.9 | 38.0 | 25.9 | 8.1 | 21.6 | 6.6 | 1.6 | 0.7 | |
| Proportion per cent. | 6.3 | 34.8 | 23.6 | 7.4 | 19.7 | 6.1 | 1.4 | 0.7 | 3069 |
| Year of Birth | 1926 | 1925 | 1924 | 1923 | 1922 | 1921 | 1920 | 1919— | |
| 1928. Catch per hour | 1.0 | 11.8 | 49.9 | 28.3 | 7.1 | 13.2 | 4.4 | 1.5 | |
| Proportion per cent. | 0.8 | 10.1 | 42.6 | 24.1 | 6.1 | 11.3 | 3.7 | 1.3 | 3640 |
| Year of Birth | 1927 | 1926 | 1925 | 1924 | 1923 | 1922 | 1921 | 1920— | |

The catch per hour, though given in the table, is disregarded in the discussion since, for the reasons given on page 76, it cannot be regarded as comparable from year

to year. The proportion per cent. is taken therefore as giving the more reliable data for the study of the fluctuations in all the samples obtained by the Research Vessel.

Since the depth of the most inshore station is seldom less than $26^1/_2$ metres, the 0-group is not found and the I-group is poorly represented at this season. The II-group again is not taken as a rule in great quantity very far off shore. It is only when the plaice have entered the III-group that the stock may be said to be fully represented along the line as a whole. If then the III-group make up a considerable proportion of the stock, the year in which they were spawned is considered as a favourable year for the survival of the brood. If, on the contrary, they account for only a small percentage of the catch, the year in which they were spawned is regarded as an unfavourable year for survival. On this assumption, the diagram shows that 1920, 1921, 1922 and 1925 were good spawning years, since with the exception of 1922, their products made up over 42 per cent. of the catch as the III-group. That the 1922 year-class was rich, however, is shown the next year, 1926, when, as the IV-group, it formed 41 per cent. of the catch; in the previous year its abundance was masked to some extent by the presence of a large proportion of the 1921 year-class (IV-group). The fish spawned in 1923 make up but a very small proportion of the catch in every age-group. The 1924 year-class was more abundant but still fell far short of the rich year-classes already mentioned.

We have therefore definite evidence of good and bad survival years in this area during the period under consideration, and the good years are in excess of the poor years. The comparative abundance of the year-classes is further discussed when dealing with the samples of commercial landings.

The plaice obtained from the same line of stations in September 1928 show very much

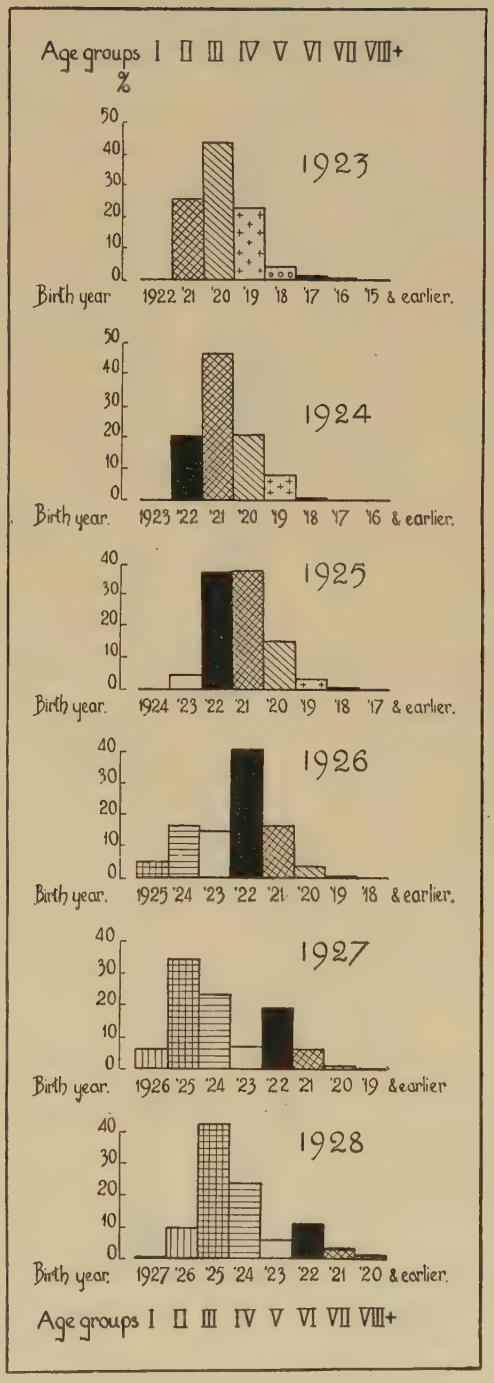


Fig. 1. Proportion per cent. of each Age-group of Plaice from the Leman Ground to the Haaks Light Vessel in May of the years 1923—1928.

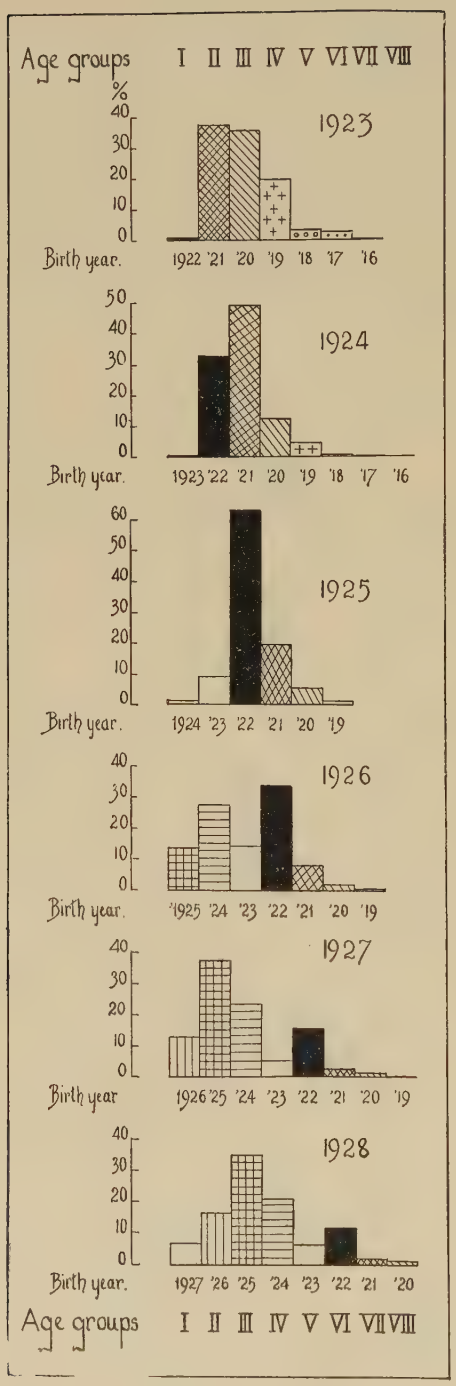


Fig. 2. Proportion per cent. of each Age-group of Plaice taken at the most easterly station of the Leman-Haaks Line in May of the years 1923—1928.

the same proportions as in May of that year. The III-group (1925 year-class) formed 35 per cent. of the catch; the II-group showed a higher percentage than in May.

The age-composition of the stock at the most inshore station of the Leman-Haaks line in May is given in Table 2 and the proportions per cent. are shown in Fig. 2. The plaice population here consists mainly of the younger fish and shows the fluctuations more markedly.

The proportions of the rich year-classes of 1920, 1921, 1922 and 1925 as the III-group were 35.4 per cent., 49.0 per cent. 62.8 per cent. and 35.0 per cent. respectively, while that of the worst year-class (1923) was only 14.2 per cent. and that of 1924, 23.8 per cent. At this station naturally, there are fewer of the older and more of the younger fish than in the whole line of stations, therefore to some extent the proportions of the II-group give some indication as to whether the spawning of the various year-classes was successful or the reverse. Thus there were 37.3 per cent., 32.3 per cent. and 37.7 per cent. of the 1921, 1922 and 1925 year-classes respectively as the II-group; the 1923 year-class formed only 9.5 per cent. and the 1924 year-class 27.8 per cent. when in that group. The percentage of the 1924 year-class is higher than would be expected from the information afforded by the whole line of stations, but it is, of course, largely dependent on the very small number of the 1923 year-class (III-group) present. While it is not possible to say as yet whether the 1926 brood was very abundant, the fact that at the comparable inshore station of the line in September 1928 it made up 34 per cent. of the total as the II-group, leads one to assume that there is probably quite a good stock.

## 2) Danish, German and Dutch Coast Investigations.

As already stated, the only sufficiently large samples for reliable comparisons were those obtained in June and November in 1926 and 1928.

Table 2. Catch per hour and Proportion per cent. of each Age-group of Plaice taken in the vicinity of the Haaks Light Vessel in May of the Years 1923—1928.

| | Age-groups | | | | | | | | No. of Otoliths examined |
|---|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI | VII | VIII | |
| Year | | | | | | | | | |
| 1923. Catch per hour | 2.0 | 72.0 | 68.5 | 38.3 | 6.8 | 5.2 | 0.5 | .. | |
| Proportion per cent. | 1.0 | 37.3 | 35.4 | 19.8 | 3.5 | 2.7 | 0.3 | .. | 332 |
| Year of Birth | 1922 | 1921 | 1920 | 1919 | 1918 | 1917 | 1916 | .. | |
| 1924. Catch per hour | 2.2 | 134.2 | 203.5 | 51.5 | 19.9 | 3.0 | 1.1 | 0.2 | |
| Proportion per cent. | 0.5 | 32.3 | 49.0 | 12.4 | 4.8 | 0.7 | 0.3 | 0.0 | 1906 |
| Year of Birth | 1923 | 1922 | 1921 | 1920 | 1919 | 1918 | 1917 | 1916 | |
| 1925. Catch per hour | 2.7 | 16.8 | 111.0 | 34.8 | 9.5 | 2.0 | .. | .. | |
| Proportion per cent. | 1.5 | 9.5 | 62.8 | 19.7 | 5.4 | 1.1 | .. | .. | 709 |
| Year of Birth | 1924 | 1923 | 1922 | 1921 | 1920 | 1919 | .. | .. | |
| 1926. Catch per hour | 35.7 | 71.5 | 36.5 | 86.8 | 21.2 | 5.0 | 0.8 | .. | |
| Proportion per cent. | 13.9 | 27.8 | 14.2 | 33.7 | 8.2 | 1.9 | 0.3 | .. | 1041 |
| Year of Birth | 1925 | 1924 | 1923 | 1922 | 1921 | 1920 | 1919 | .. | |
| 1927. Catch per hour | 26.5 | 77.2 | 48.8 | 10.5 | 32.3 | 5.3 | 3.0 | 1.0 | |
| Proportion per cent. | 12.9 | 37.7 | 23.8 | 5.1 | 15.7 | 2.6 | 1.5 | 0.5 | 820 |
| Year of Birth | 1926 | 1925 | 1924 | 1923 | 1922 | 1921 | 1920 | 1919 | |
| 1928. Catch per hour | 6.0 | 14.0 | 30.4 | 18.0 | 5.3 | 10.0 | 1.7 | 1.0 | |
| Proportion per cent. | 6.9 | 16.2 | 35.0 | 20.8 | 6.2 | 11.5 | 1.9 | 1.1 | 260 |
| Year of Birth | 1927 | 1926 | 1925 | 1924 | 1923 | 1922 | 1921 | 1920 | |

Table 3. Catch per hour and Proportion per cent. of each Age-group of Plaice caught at certain stations in June 1926 and June 1928.

| Date | Station | Position | No. of Otoliths examined | Age-groups | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | |
| ne 1926 | 1. Horn | 55°22′ N. | 560 | .. | 218 | 1134 | 1777 | 194 | 42 | 6 | .. | .. | .. | .. | Catch per hour. |
| | Reef | 7°42′ E. | | .. | 6.5 | 33.6 | 52.7 | 5.7 | 1.3 | 0.2 | .. | .. | .. | .. | Proportion per cent. |
| ne 1928 | 2. Horn | 55°23′ N. | 643 | .. | 0 | 23 | 15 | 19 | 22 | 0 | 1 | .. | .. | .. | Catch per hour. |
| | Reef | 7°27′ E. | | .. | 0.5 | 28.8 | 18.7 | 23.4 | 27.7 | 0.3 | 0.6 | .. | .. | .. | Proportion per cent. |
| ne 1926 | 2. Graa | 55°22′ N. | 585 | .. | 91 | 400 | 835 | 91 | 22 | 3 | .. | .. | .. | .. | Catch per hour. |
| | Dyb | 8°5′ E. | | .. | 6.3 | 27.7 | 57.9 | 6.3 | 1.6 | 0.2 | .. | .. | .. | .. | Proportion per cent. |
| ne 1928 | 1. Graa | 55°22′ N. | 1034 | 2 | 160 | 711 | 121 | 81 | 95 | .. | .. | .. | .. | .. | Catch per hour. |
| | Dyb | 7°54′ E. | | 0.2 | 13.7 | 60.8 | 10.3 | 6.9 | 8.1 | .. | .. | .. | .. | .. | Proportion per cent. |
| ne 1926 | 5. Near | 54°23′ N. | 553 | .. | 15 | 74 | 147 | 45 | 23 | 17 | 2 | .. | .. | .. | Catch per hour. |
| | Heligoland | 7°59′ E. | | .. | 4.7 | 22.8 | 45.5 | 13.8 | 7.2 | 5.3 | 0.7 | .. | .. | .. | Proportion per cent. |
| ne 1928 | 4. Near | 54°17′ N. | 476 | .. | 0 | 1 | 2 | 4 | 10 | 5 | 4 | 3 | 1 | 0 | Catch per hour. |
| | Heligoland | 7°30′ E. | | .. | 0.6 | 4.8 | 7.4 | 12.4 | 32.1 | 16.2 | 14.3 | 10.5 | 1.5 | 0.2 | Proportion per cent. |

The three stations that were trawled in approximately the same areas in June of the two years are given in Table 3. Off the Danish coast (Figs. 3 and 4), the proportions agree broadly with those of the Leman Haaks Line since the 1922 year-class (IV-group) predominated in 1926 and the 1925 year-class (III-group) in 1928. In the graphs of both stations there is a secondary mode of the VI-group (1922 year-class) in 1928 which indicates that the year-classes of 1923 and 1924 were less abundant than that of 1922.

At the third station near Heligoland (Fig. 5) the 1922 year-class again predominated in 1926, but it is hardly permissible to make a comparison between the June samples in the two periods, since in June 1926 the depth of trawling was 17 to 20 metres and in 1928, 29 to 31 metres. Plaice were very scarce in the area sampled in 1928 and consisted mainly of the VI-group and older fish, the VI-group (1922 year-class) forming 32 per cent. It is obvious that the younger fish had not moved into this area and therefore there is no indication of the general age-composition of the stock.

Three other stations were trawled in June 1928 (Table 4, Fig. 6), viz. off Sylt, near Schiermonnikoog and near the Haaks Light Vessel.

Table 4. Catch per hour and Proportion per cent. of each Age-group of Plaice caught at certain stations in June 1928.

| Date | Station | Position | No. of Otoliths examined | Age-groups | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII | |
| June 1928 | 3. Off Sylt | 55°00′ N. | 1022 | .. | 260 | 1077 | 245 | 295 | 284 | 7 | 2 | .. | .. | .. | .. | Catch per hour. |
| | | 7°55′ E. | | .. | 12.0 | 49.6 | 11.3 | 13.6 | 13.1 | 0.3 | 0.1 | .. | .. | .. | .. | Proportion per ce |
| June 1928 | 5. Schier- | 53°45′ N. | 1025 | 117 | 435 | 470 | 282 | 36 | 44 | 15 | 4 | 1 | .. | .. | .. | Catch per hour. |
| | monnikoog | 5°46′ E. | | 8.3 | 31.0 | 33.5 | 20.1 | 2.5 | 3.1 | 1.1 | 0.3 | 0.1 | .. | .. | .. | Proportion per ce |
| June 1928 | 6. Haaks | 52°54′ N. | 711 | 13 | 118 | 66 | 19 | 2 | 12 | 2 | 2 | 1 | 0 | 0 | 1 | Catch per hour. |
| | L.V. | 4°15′ E. | | 5.4 | 49.8 | 27.9 | 8.1 | 1.0 | 5.2 | 0.9 | 0.8 | 0.4 | 0.1 | 0.1 | 0.3 | Proportion per ce |

Off Sylt, as was the case in the other two areas off the Danish Coast, the 1925 year-class predominated. Near Schiermonnikoog the same year-class was again the most numerous but there was evidently a strong brood from the 1926 spawning (II-group), which was nearly as abundant. This 1926 year-class was by far the most numerous near the Haaks Light Vessel, while the 1925 year-class was next in importance.

Approximately the same six areas were trawled in November 1926 and 1928 as in June 1928. (Table 5.)

At the three stations off the Danish Coast much the same age distribution was found as in June in the two years; that is to say, the 1922 year-class predominated in 1926 and the 1925 year-class in 1928. There is no indication of an abundant 1926 year-class (II-group) in 1928 which was shown to have been plentiful off the Dutch coast in June and September.

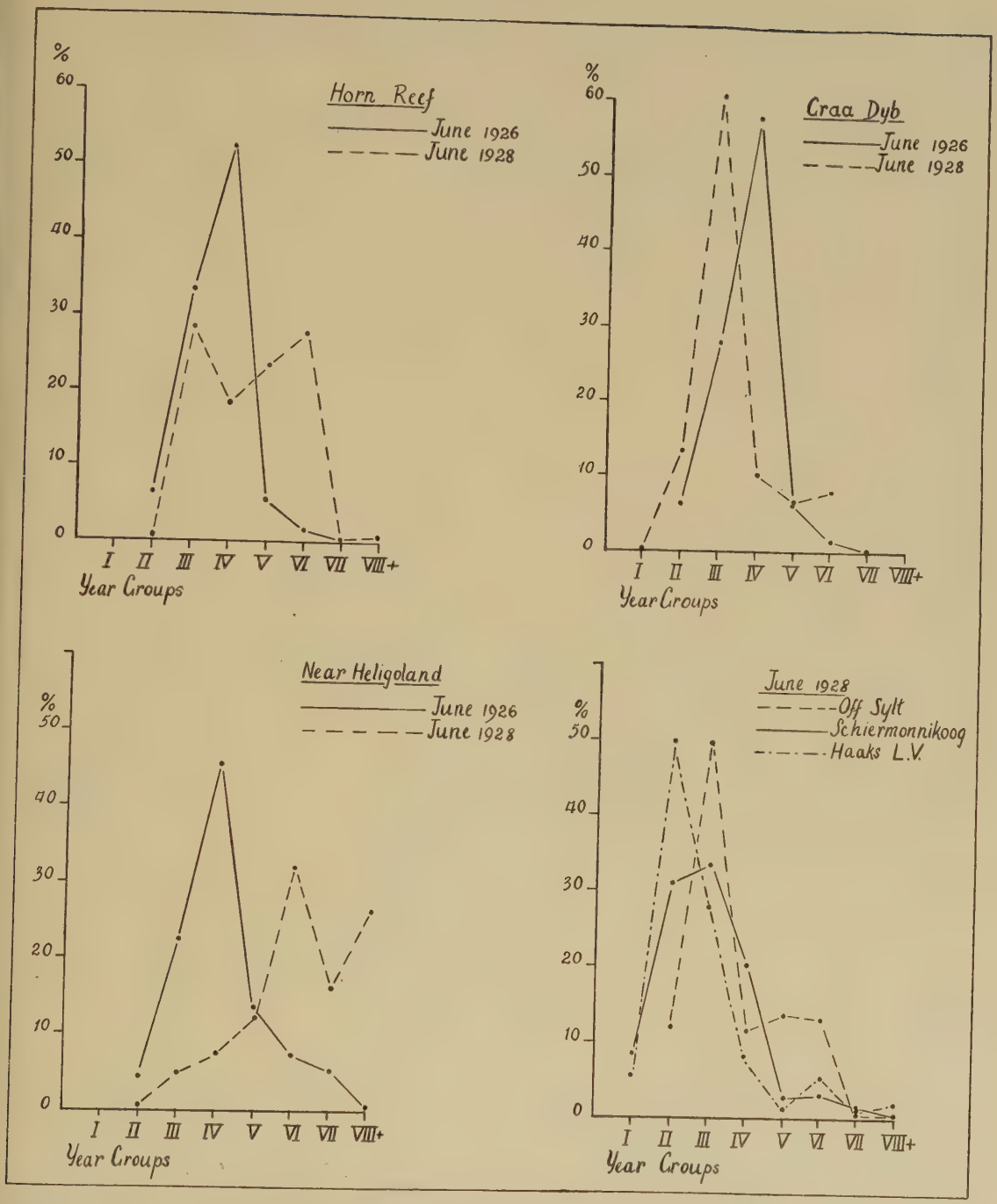


Fig. 3. Proportion per cent. of each Age-group of Plaice taken near Horn Reef in June 1926 and 1928.
Fig. 4. Proportion per cent. of each Age-group of Plaice taken at Graa Dyb in June 1926 and 1928.
Fig. 5. Proportion per cent. of each Age-group of Plaice taken near Heligoland in June 1926 and 1928.
Fig. 6. Proportion per cent. of each Age-group of Plaice taken off Sylt, near Schiermonnikoog and the Haaks Light Vessel in June 1928.

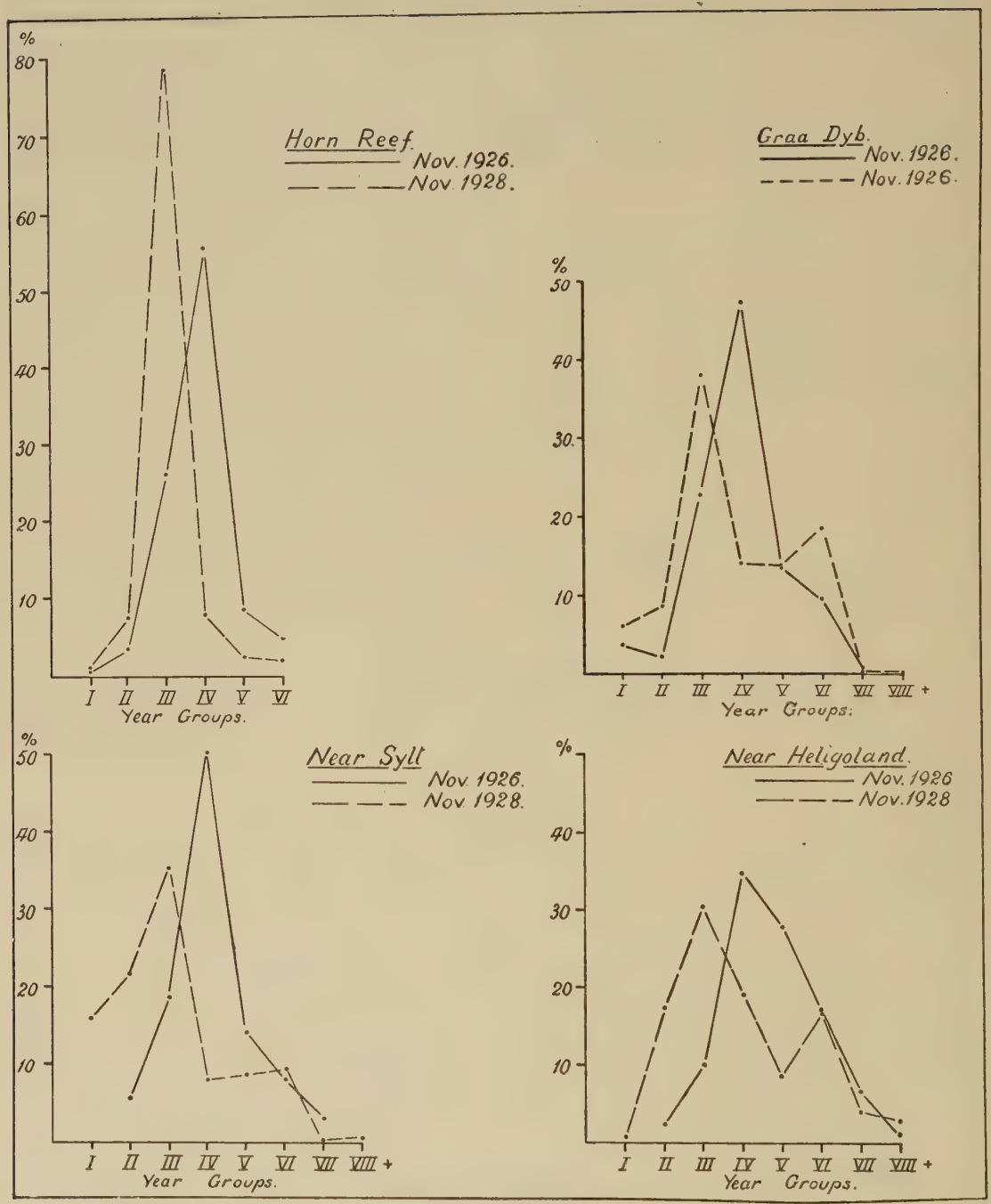


Fig. 7. Proportion per cent. of each Age-group of Plaice taken near Horn Reef in November 1926 and 1928.
Fig. 8. Proportion per cent. of each Age-group of Plaice taken at Graa Dyb in November 1926 and 1928.
Fig. 9. Proportion per cent. of each Age-group of Plaice taken near Sylt in November 1926 and 1928.
Fig. 10. Proportion per cent. of each Age-group of Plaice taken near Heligoland in November 1926 and 1928.

e 5. Catch per hour and Proportion per cent. of each Age-group of Plaice caught ertain stations off the Danish, German and Dutch Coasts in November, 1926 and November, 1928.

| te | Station | Position | No. of Otoliths examined | Age-groups | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 0 | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XIV | |
| 1926 | 9. Horn Reef | 55°25′ N. 7°28′ E. | 420 | .. .. | 0 0.5 | 4 3.8 | 28 26.3 | 59 55.8 | 9 8.8 | 5 4.8 | .. .. | .. .. | .. .. | .. .. | .. .. | .. .. | Catch per hour. Proportion per cent. |
| 1928 | 1. Horn Reef | 55°30′ N. 7°16′ E. | 492 | .. .. | 3 0.8 | 31 7.7 | 309 78.6 | 32 8.2 | 10 2.5 | 9 2.2 | .. .. | .. .. | .. .. | .. .. | .. .. | .. .. | Catch per hour. Proportion per cent. |
| 1926 | 10. Graa Dyb | 55°20′ N. 7°53′ E. | 385 | .. .. | 3 3.7 | 2 2.3 | 22 22.7 | 46 47.4 | 13 13.5 | 9 9.6 | 1 0.8 | .. .. | .. .. | .. .. | .. .. | .. .. | Catch per hour. Proportion per cent. |
| 1928 | 2. Graa Dyb | 55°21′ N. 7°59′ E. | 490 | 0 0.2 | 3 6.1 | 4 8.4 | 17 38.3 | 7 14.3 | 6 13.9 | 8 18.4 | 0 0.2 | .. .. | 0 0.2 | .. .. | .. .. | .. .. | Catch per hour. Proportion per cent. |
| 1926 | 8. Near Sylt | 54°58′ N. 7°57′ E. | 288 | .. .. | .. .. | 4 5.6 | 14 18.8 | 36 50.2 | 10 14.3 | 6 8.0 | 2 3.1 | .. .. | .. .. | .. .. | .. .. | .. .. | Catch per hour. Proportion per cent. |
| 1928 | 3. Near Sylt | 54°50′ N. 7°50′ E. | 573 | 2 0.2 | 228 15.9 | 313 21.8 | 505 35.3 | 115 8.0 | 125 8.7 | 135 9.4 | 3 0.2 | 5 0.3 | 2 0.2 | .. .. | .. .. | .. .. | Catch per hour. Proportion per cent. |
| 1926 | 5. Near Heligoland | 54°18½′ N. 7°29′ E. | 450 | .. .. | .. .. | 3 2.4 | 11 10.0 | 39 34.9 | 31 27.6 | 19 17.1 | 8 6.7 | 1 1.1 | .. .. | 0 0.2 | .. .. | .. .. | Catch per hour. Proportion per cent. |
| 1928 | 4. Near Heligoland | 54°14′ N. 7°34′ E. | 393 | .. .. | 0 0.8 | 6 17.4 | 10 30.5 | 6 19.2 | 3 8.5 | 6 16.7 | 1 4.1 | 1 1.8 | 0 0.8 | .. .. | .. .. | 0 0.2 | Catch per hour. Proportion per cent. |
| 1926 | 3. Schiermonnikoog | 53°42′ N. 5°48′ E. | 1253 | .. .. | 95 11.2 | 293 34.4 | 171 20.1 | 201 23.6 | 68 8.0 | 20 2.3 | 4 0.4 | .. .. | .. .. | .. .. | .. .. | .. .. | Catch per hour. Proportion per cent. |
| 1928 | 5. Schiermonnikoog | 53°46′ N. 5°55′ E. | 1221 | .. .. | 161 52.6 | 88 28.8 | 36 11.8 | 14 4.5 | 2 0.7 | 4 1.5 | 0 0.1 | .. .. | .. .. | .. .. | .. .. | .. .. | Catch per hour. Proportion per cent. |
| 1926 | 1. Off Ymuiden. | 52°33′ N. 4°10′ E. | 613 | 0 0.2 | 27 34.9 | 25 33.0 | 8 10.6 | 12 14.8 | 4 5.1 | 1 0.8 | 0 0.3 | 0 0.3 | .. .. | .. .. | .. .. | .. .. | Catch per hour. Proportion per cent. |
| 1928 | 6. Haaks L.V. | 52°55′ N. 4°15′ E. | 557 | .. .. | 30 21.8 | 60 43.1 | 26 18.9 | 8 5.6 | 3 1.8 | 8 5.8 | 3 2.2 | 1 0.4 | .. .. | .. .. | 0 0.4 | .. .. | Catch per hour. Proportion per cent. |

Near Heligoland again the 1922 year-class predominated in November 1926 as in June of that year. In November 1928, however, although trawling was carried out in deeper water than in June 1928, the older fish with the exception of the VI-group (1922 year-class) had largely disappeared. Plaice were still scarce but the III-group (1925 year-class) predominated.

Off the Dutch coast (Figs. 11 and 12) the age-composition of the stock was very different from that found in the areas further north.

Here there are evidently some conditions that are more favourable for younger

fish than further north and the older fish have migrated to some extent. In November 1926 at both stations the II-group (1924 year-class) was more abundant than the IV-group (1922 year-class) which predominated elsewhere, yet our other evidence shows that this group was not in reality a very abundant one. Again the percentage proportions in November 1928 at Schiermonnikoog differed greatly from those found in June 1928. In the summer, the stock consisted largely of the II and III-groups and in autumn of the I- and II-groups. Near the Haaks Light Vessel, the II-group was far the most numerous in both June and November 1928.

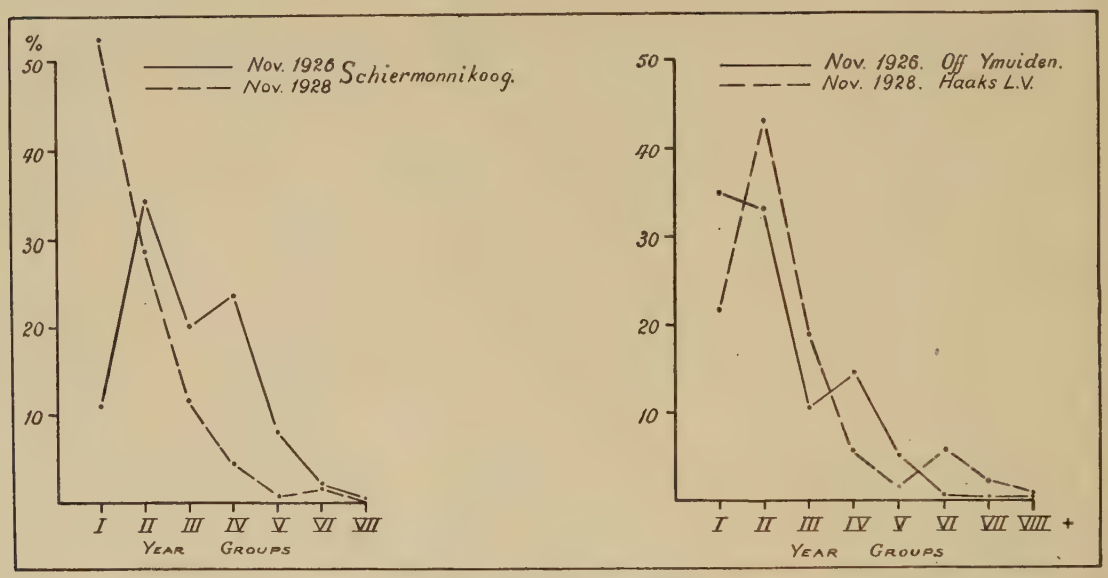


Fig. 11. Proportion per cent. of each Age-group of Plaice taken near Schiermonnikoog in November 1926 and 1928.

Fig. 12. Proportion per cent. of each Age-group of Plaice taken off Ymuiden in November 1926 and near the Haaks Light Vessel in November 1928.

### 3) Trade Category Samples.

There is reason to hope that from the collection of these samples and their application to the total catch per 100 hours' fishing of the landings of 1st Class Steam Trawlers at Lowestoft for the months in which they were taken considerable information will be obtained with regard to the stock of plaice in the southern North Sea. The objects are threefold; first to show the relative abundance of each year-class when the fish are old enough to be marketable; second, to estimate the effect of fishing and other factors in reducing the stock; and third, to test the effect that fluctuations may have on the amount and value of the landings. While these samples have only been collected during the last three years, they already show significant results.

1) It has been realised that the catch per hour of plaice caught by the research vessel is based on too short a time from which to make reliable comparison from year

Table 6. Total landings, percentages and catch per 100 hours fishing by numbers and weight (cwts.) of each age-group of Plaice landed at Lowestoft by 1st Class Steam Trawlers.

| riod | Age-groups ..... | I | II | III | IV | V | VI + | Total |
|---|---|---|---|---|---|---|---|---|
| | Year-class ..... | | 1924 | 1923 | 1922 | 1921 | 1920 & earlier | |
| ct. 926 | Total Number .. | .. | 14,573 | 155,059 | 404,501 | 275,704 | .. | .. |
| | 100 hrs. Fishing.. | .. | 135 | 1,432 | 3,734 | 2,545 | .. | .. |
| | Total Weight Cwts | — | 36 | 491 | 1,617 | 1,479 | 1,468 | 5,091 |
| | Weight per cent.. | .. | 0.7 | 9.6 | 31.8 | 29.1 | 28.8 | .. |
| | 100 hrs. Fishing.. | .. | 0.3 | 4.5 | 14.9 | 13.7 | 13.6 | 47 |

| riod | Age-groups..... | I | II | III | IV | V | VI | VII | VIII | IX | X | XI+ | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Year-class ..... | | 1925 | 1924 | 1923 | 1922 | 1921 | 1920 | 1919 | 1918 | 1917 | 1916 & earlier | |
| ec. 927 | Total Number... | .. | 40,752 | 100,571 | 92,261 | 292,481 | 159,949 | 54,304 | 29,803 | 9,077 | 7,615 | 29,383 | 816,196 |
| | Number per cent. | .. | 5.0 | 12.3 | 11.3 | 35.8 | 19.6 | 6.7 | 3.7 | 1.1 | 0.9 | 3.6 | .. |
| | 100 hrs. Fishing.. | .. | 184 | 453 | 416 | 1,318 | 721 | 245 | 134 | 41 | 34 | 132 | 3,678 |
| | Total Weight Cwts | .. | 100 | 282 | 380 | 1,555 | 1,219 | 590 | 399 | 159 | 159 | 705 | 5,548 |
| | Weight per cent.. | .. | 1.8 | 5.1 | 6.8 | 28.0 | 22.0 | 10.6 | 7.2 | 2.9 | 2.9 | 12.7 | .. |
| | 100 hrs. Fishing.. | .. | 0.4 | 1.3 | 1.7 | 7.0 | 5.5 | 2.7 | 1.8 | 0.7 | 0.7 | 3.2 | 25 |

| riod | Year-class ..... | 1927 | 1926 | 1925 | 1924 | 1923 | 1922 | 1921 | 1920 | 1919 | 1918 | 1917 & earlier | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ec. 928 | Total Number... | 7,916 | 136,455 | 292,658 | 152,435 | 69,863 | 162,829 | 90,621 | 33,654 | 18,062 | 9,610 | 19,480 | 993,583 |
| | Number per cent. | 0.8 | 13.7 | 29.5 | 15.3 | 7.0 | 16.4 | 9.1 | 3.4 | 1.8 | 1.0 | 2.0 | .. |
| | 100 hrs. Fishing.. | 30 | 516 | 1,107 | 577 | 264 | 616 | 343 | 127 | 68 | 36 | 74 | 3,758 |
| | Total Weight Cwts. | 20 | 346 | 940 | 606 | 529 | 1,455 | 989 | 482 | 333 | 185 | 461 | 6,346 |
| | Weight per cent.. | 0.3 | 5.5 | 14.8 | 9.6 | 8.3 | 22.9 | 15.6 | 7.6 | 5.2 | 2.9 | 7.3 | .. |
| | 100 hrs. Fishing.. | 0.1 | 1.3 | 3.6 | 2.3 | 2.0 | 5.5 | 3.7 | 1.8 | 1.3 | 0.7 | 1.7 | 24 |

to year. The conditions of trawling such as weather, shoaling of fish and other factors may cause erroneous impressions. With the trade category samples, however, the basis from which conclusions are drawn is very much broader since it is possible to raise these samples to the thousands of cwts. landed by vessels that have trawled for hundreds of hours over a wide area and to reduce them to the common unit of the catch per 100 hours' fishing.

The investigations were first started in October 1926. It was not possible in this month to obtain sufficiently big samples of the plaice known as "Large" and "Best"

on the market to calculate their ages, but since examination of the otoliths showed that the next category, that of "Medium" consisted of plaice older than the V-group,

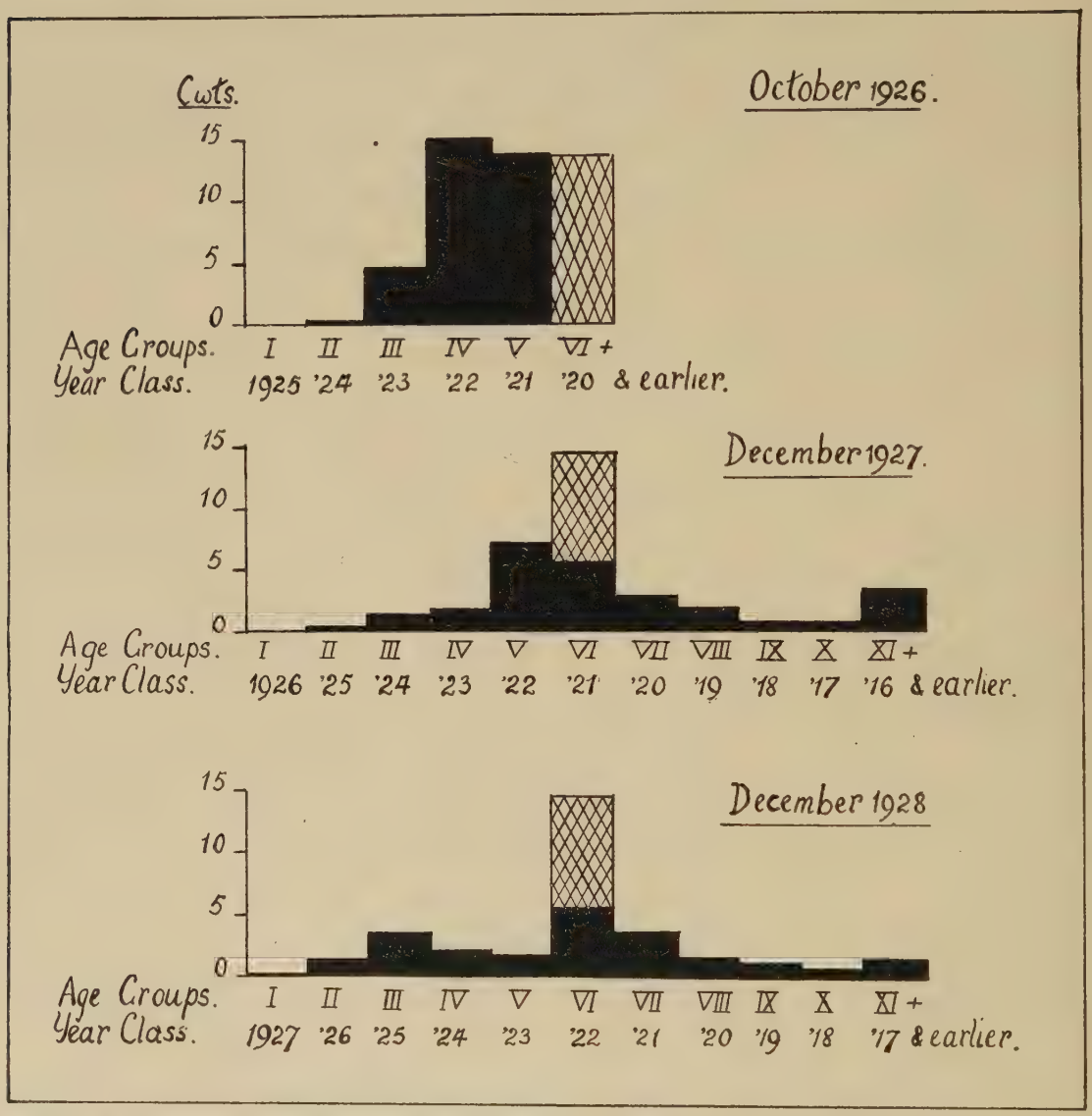


Fig. 13. Total Weight (cwts.) of the catch per 100 hours' fishing of each Age-group of Plaice landed at Lowestoft in certain periods by 1st Class Steam Trawlers.

"Large" and "Best" were regarded as belonging to the VI and older groups. These are shown by the cross hatched column in Fig. 13. In the succeeding periods, December of 1927 and 1928, full samples were obtained and it was possible to calculate the ages of all plaice up to the XI-group; the rings on the otoliths of older fish were sometimes too

indefinite to determine exactly. For the sake of comparison the VII and older groups are also shown by cross hatching in the diagrams.

The three periods given in Fig. 13 are not strictly comparable one with another since the 1926 sample was taken in October when more young plaice would be likely to be present on the grounds than in December when the fishery is largely for the mature plaice that have collected together for spawning. These seasonal variations, however, are not sufficiently great to account for differences of such magnitude in the weight of the catch per 100 hours' fishing of the IV and V year-groups in succeeding years; these groups moreover would be present on the fishing grounds both in October and December.

The weight of the 1922 year-class as the IV-group in 1926 was 14.9 cwts., while the same group of the 1923 and 1924 year-classes were only 1.7 cwts. and 2.3 cwts. respectively in 1927 and 1928. Similarly with the V-group the catch per 100 hours' of the 1921 year-class was 13.7 cwts., of the 1922 year-class 7.0 cwts. and the 1923 year-class 2.0 cwts.

Owing to the possible seasonal variations between October and December the III-group is only comparable in the last two years. In 1927 as the 1924 year-class, the catch per 100 hours' was 1.3 cwts. and in 1928 as the 1925 year-class 3.6 cwts. or nearly three times as great.

The number caught per 100 hours' fishing gives the actual abundance of each age-group more clearly since the fish grow heavier with age. It is shown in Fig. 14 for the two strictly comparable periods December of 1927 and 1928.

In 1927 the V-group was derived from the rich year-class of 1922 and 1,318 were caught per 100 hours', in 1928 the poor year-class of 1923 was the V-group and only 264 were taken or 80 per cent. less. The year-class of 1924 was not much better as the IV-group in 1928 than the year-class of 1923 as the IV-group in 1927, while the III-group (1925 year-class) in 1928 was more than twice as abundant as the 1924 year-class in the previous year. The effect of fluctuations on the abundance of the various year-classes is therefore very marked in the commercial landings.

2) When discussing these commercial samples, however, there are other factors that must be taken into consideration; in the first place, the younger fish up to the III-group are not as a rule fully represented in the winter landings since they are further inshore or else have buried themselves in the sand, particularly the less well grown specimens of the groups; also the majority of plaice of under 22 cms. are rejected by the trawlers before landing. Fewer fish of a year-class are landed, therefore, when they are in the II and III groups than when they are in the III and IV year-groups at this season. Secondly, after the IV-group is reached the effect of fishing and other causes in reducing the stock is evident. The extent of the increase or reduction of the catch per 100 hours' fishing of each year-class between December 1927 and December 1928 is as follows:—

| Between Age-groups ..... | III-IV | IV-V | V-VI | VI-VII | VII-VIII | VIII-IX |
|---|---|---|---|---|---|---|
| Increase or reduction by number, per cent. | +27 | —37 | —53 | —52 | —48 | —49 |
| Increase or reduction by weight, per cent. | +77 | +18 | —21 | —33 | —33 | —28 |
| Year-class ..... | 1924 | 1923 | 1922 | 1921 | 1920 | 1919 |

These figures lead to the supposition that a year-class reaches its maximum in the landings as the IV-group and that after that age it undergoes a very rapid reduction

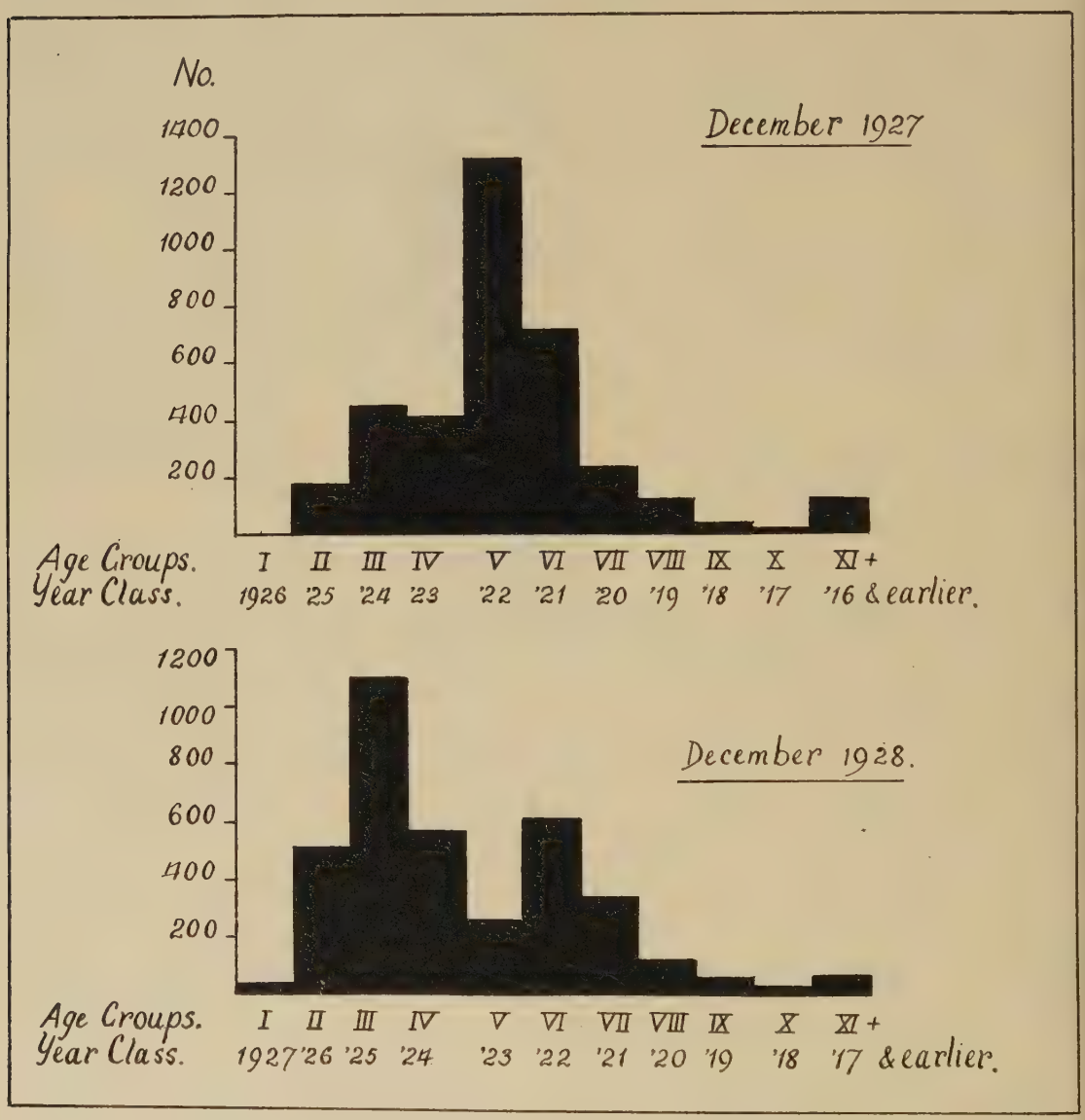


Fig. 14. Total number of the catch per 100 hours' fishing of each Age-group landed at Lowestoft by 1st Class Steam Trawlers in December 1927 and 1928.

by number. By weight, however, owing to natural increase the reduction is neither so rapid nor great. Further sampling should show this more exactly.

3) The practical point as to how far natural fluctuations affect the value of the landings from the commercial standpoint is beyond the scope of this report; moreover,

it cannot be determined very exactly till further data have been obtained. Such material that has been collected, however, appears to indicate that the abundance of the IV and V year-groups has a significant effect. Thus in October 1926 when both these year-groups (1922 and 1921 year-classes) were very numerous, the value of the catch per 100 hours' fishing was approximately £103; in December 1927 when the V year-group (1922 year-class) was rich and the IV year-group was poor, the value was £68; in December of the following year, when both were scarce (1923 and 1924 year-classes), the value fell to £64. But as already stated, in order to confirm this supposition, further work must be done, and it must be remembered that it only refers to samples obtained in the Autumn and Winter. In order to collect fuller information, samples of market categories were also obtained in April 1928 and it is intended that in future samples shall be collected in spring each year.

## Summary.

Collections of otoliths of Plaice have been examined from samples taken by the Ministry's Research Vessel from a line of stations trawled from the Leman ground to the Haaks Light Vessel in May of the years 1923 to 1928 and September 1928; off the Danish and German coasts in June 1926; off the Danish, German and Dutch coasts in November, 1926, June and November 1928.

The examination shows that the year-classes of plaice spawned in 1920, 1921, 1922 and 1925 were abundant, while those spawned in 1923 and 1924 were scarce in the Southern North Sea. It is also probable that the year-class spawned in 1926 was abundant off the Dutch coast.

The conclusions drawn from these experiments are confirmed as far as the 1925 and earlier year-classes are concerned by the examination of samples of otoliths of the market categories of plaice landed at Lowestoft collected in October 1926, and December of 1927 and 1928, which were applied both by number and weight to the total catch per 100 hours' fishing of steam trawlers landing at that port.

It is hoped that further work on the same lines will throw light on the yearly toll levied on the stock by mortality from fishing and other causes. The data so far obtained indicate that each age-group over the V-group is reduced by about 50 per cent. in number in the course of a year's fishing, but that the reduction by weight is considerably less owing to natural increase in weight of the fish.

# X. On a correlation between the yearly catch of Herring in the Sound and the abundance of Herring Larvae in autumn.

By

**A. C. Johansen.**

The herring fishery in the Sound is based upon one single race, namely the Sound Herring, the spawning time of which is September and the beginning of October. The fishery for this herring in the Sound takes place in the period August—November, and the catch consists predominantly of mature fish.

Since the year 1925 regular fishing experiments with a 2 metres stramin ring-trawl have been carried out in the Sound in the month of October in order to investigate the abundance of the herring larvae. The experiments show that in the course of the years from 1925 to 1928 there has been a steady and strong increase in the number of herring larvae corresponding to an increase — but a somewhat lesser increase — in the yearly yield of the Herring fisheries.

The yield of the Danish Herring fisheries in the Sound and the number of Herring Larvae caught per 30 minutes' haul with the 2 metres ring-trawl were as follows:—

| Year | Yield in tons of the herring fishery | No. of herring larvae caught per fishing unit | No. of stations for fishing experiments |
|---|---|---|---|
| 1925..... | 266 | 6 | 15 |
| 1926..... | 485 | 14 | 8 |
| 1927..... | 622 | 73 | 13 |
| 1928..... | c. 800 | 161 | 17 |

If we compare the yield of the Danish herring fishery in the Sound and adjacent parts of the Baltic until the line Möen Cliff North — Smygehuk, with the catch of herring larvae per 30 minutes' haul in October in the same area, we obtain the following result:—

| Year | Yield in tons of the herring fishery | No. of herring larvae caught per fishing unit | No. of stations for fishing experiments[1]) |
|---|---|---|---|
| 1925..... | 334 | 16 | 23 |
| 1926..... | 609 | 21 | 23 |
| 1927..... | 974 | 78 | 20 |
| 1928..... | c. 1300 | 160 | 19 |

[1]) Swedish Stations included.

It should be mentioned in this connection that the Haddock, which normally feeds eagerly upon herring-spawn, is not present in the Baltic and the southern part of the Sound, where the spawning places of the Sound Herring occur.

The herring larvae caught in the Sound in the month of October have almost all a length between 5 and 16 mm. The external conditions during the following winter (temperature, food, enemies etc.) play undoubtedly a great rôle for their fate.

In the course of some few years we shall be able to see whether an abundant 0-Gr. in the autumn of a certain year, will be followed by an abundant III-Gr. 3 years later, and an abundant IV-Gr. 4 years later and so on.

As is well known Aage J. C. Jensen has produced some evidence in favour of the view that the quantity of spawning herring in the southern Baltic and the Sound has a considerable influence upon the size of the stock in some following years[1]). The investigations mentioned above would seem to be in favour of the view set forth by Jensen.

By the study of the causes of fluctuations in the abundance of fry of different kinds of marine food-fishes from year to year it has been established that the principal reason for the fluctuations cannot be sought in the fluctuations in the stock of spawning fish[2]). But though fluctuations in the stock of spawning fish is not a principal factor for the fluctuations in the quantity of fry, it is, however, a factor we dare not omit to take into consideration.

[1]) Aage J. C. Jensen: On the Influence of the Quantity of Spawning Herring upon the stock of the following years. Journal du Conseil. Vol. II. 1. 1927.

[2]) Comp. e. g. Johan Hjort: Fluctuations in the great Fisheries of Northern Europe. Rapports & Procès-Verbaux, Vol. XX. 1914.

A. C. Johansen: On the Fluctuations in the Quantity of Young Fry among Plaice and certain other species of fish, and causes of the same. Report XXXIII of the Danish Biological Station. 1927.

# XI. Fluctuations de la *Sardina pilchardus* (Walbaum) dans les côtes Océaniques.[1])

Par

**Fernando de Buen,**

Chef de Biologie.

Ce premier travail sur les fluctuations de la sardine (*Sardina pilchardus*), en ce qui concerne sa pêche, ses grandeurs et poids, se trouve pour la plus grande part sans précédent et est incomplet à cause de l'insuffisance des données accumulées.

Nous pouvons connaître la pêche et ses changements en consultant les statistiques officielles, mais, en échange, on se rend compte du manque absolu de mesures prises de la sardine pendant une série successive d'années.

Mieux documentés sur la pêche, nous nous occuperons d'elle de préférence; nous étudierons ses fluctuations, sans oublier de tenir en compte les mesures, même rares, que nous avons pu recueillir, pour établir en suite des comparaisons.

Dorénavant il sera, sans doute, possible de faire l'intéressante étude des catégories annuelles d'individus, associés par leur longueur, poids ou leur âge. Les Laboratoires côtiers de l'Institut Espagnol d'Oceanographie ont déjà commencé a recueillir régulièrement les données nécessaires.

I.—Pour connaître la répartition de la pêche de la sardine sur le littoral européen de l'Atlantique, nous prenons pour base l'année de 1920. Nous avons devant nous des statistiques officielles anglaises, françaises et espagnoles, indiquées en poids, alors que la statistique officielle portugaise ne donne que la valeur en "escudos".

En signalant sur la carte d'Europe (fig. 1) une frange noire de largeur relative à la quantité (poids en kilogrammes) débarquée en chaque port de la côte, on voit ressortir spécialement, des côtes espagnoles, Vigo et Isla Christina, et puis Douarnenez et Concarneau en France.

Si nous connaissions le poids des sardines débarquées dans les ports portugais, nous les trouverions sûrement similaires en richesse à ceux de Vigo et de Isla Christina en Espagne; mais le manque absolu de ces détails pour l'année de 1920 nous empêche toute affirmation.

[1]) Dans les publications de l'Institut Espagnol d'Océanographie nous donnerons le travail complet dont le resumé est celui-ci.

Dans le Canal de la Manche il y a plus de sardines, ou pour le moins on en pêche en plus grande abondance, sur le littoral anglais que sur celui de la France.

En admettant dans l'Europe atlantique seulement trois races de sardines, nous pouvons arriver à la conclusion suivante:

Fig. 1. Sardine débarquée à la côte atlantique de l'Europe. Année 1920.

Entre les différentes races, bien connues, de l'Europe atlantique, la race méridionale, par son abondance d'individus, et sa richesse de pêche, occupe le premier lieu, puis vient celle du Golfe de la Gascogne, et la plus pauvre est celle de la Manche.

II.—Nous passerons en revue les fluctuations que subit la sardine pendant les 12 mois de l'année, en comparant les caractéristiques de chaque région de pêche.

Sur la côte anglaise il y a une grande différence entre les mois signalant une abondance de pêche: août à octobre (figs. 2, 3 et 4), les mois restants démontrent une grande rareté. La sardine se pêche en plus grande quantité au moment de sa maturité sexuelle.

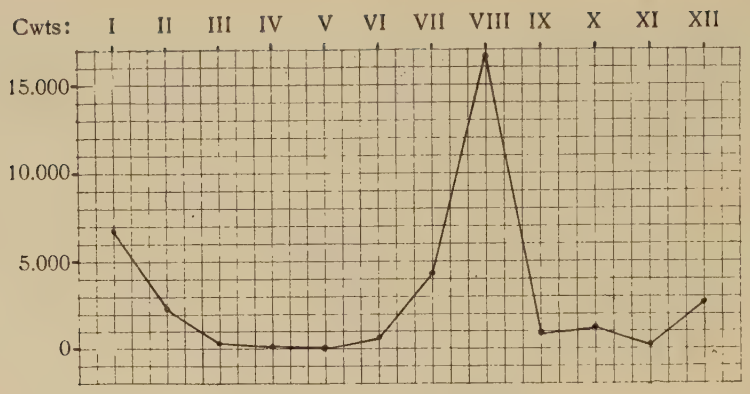


Fig. 2. Sardine débarquée dans les côtes d'Angleterre. Année 1920.

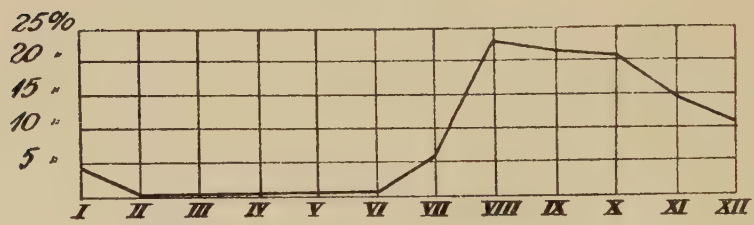


Fig. 3. Sardine débarquée dans les côtes d'Angleterre. Années 1887—1902 (d'après Hoek).

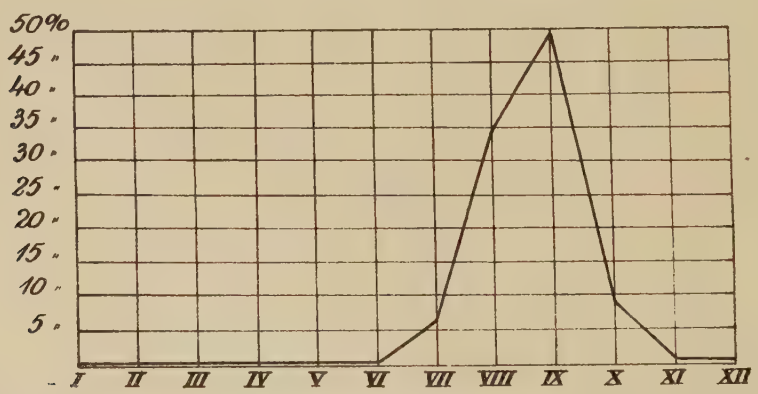


Fig. 4. Sardine débarquée dans les côtes d'Angleterre. Années 1906—1911 (d'après Hoek).

Nous disposons de peu d'information du littoral français, et seulement du port de Saint-Jean-de-Luz pendant les années de 1926 et 1927 (fig. 5). On observe une rareté notable pendant l'été, phénomène qui se pourra expliquer par une courte émigration vers l'Ouest, déjà indiquée par moi dans un autre travail (1928).

Sur les côtes de l'Espagne, le graphique de la pêche mensuelle change notablement. A Santander (fig. 6), le maximum se constate (1919—1928) au mois de janvier, et le minimum en mars et avril.

En suivant la côte espagnole, dans le port sardinier principal du NW., Vigo (1906—1915) la pêche diminue essentiellement dans les premiers mois de l'année, alors que, au contraire, les plus grandes quantités correspondent aux mois de mai à décembre (fig. 7).

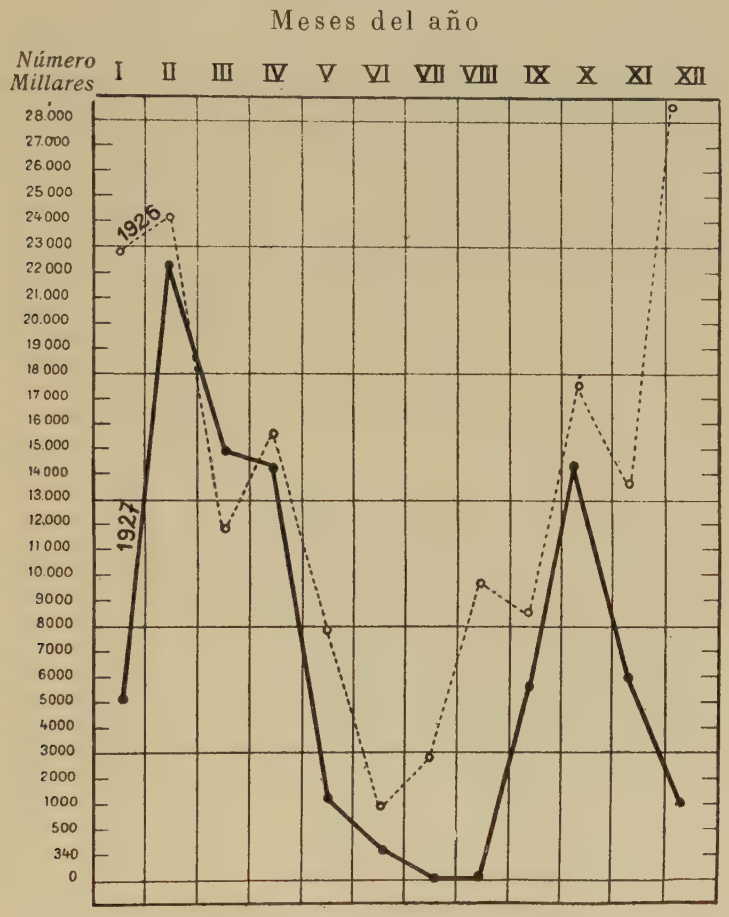


Fig. 5. Sardine débarquée à Saint-Jean-de-Luz, France (d'après Arné).

Des côtes portugaises il nous manque des données précises; les statistiques officielles emploient comme unité les "escudos", sans indiquer le poids de la sardine désembarquée. Dans l'absence d'autres éléments de base, et avec les réserves nécessaires, nous avons donc utilisé les valeurs en "escudos".

Au Portugal on constate une pêche hivernale plus intense que dans le reste de l'année à Setubal (1920); dans les ports situés plus au Nord, les caractéristiques sont similaires à celles de Vigo, et vers le Sud à celles de Isla Cristina.

Dans ce dernier port espagnol, la pêche manque dans les premiers mois, augmentant après successivement jusqu'au mois d'octobre, pour descendre brusquement dans les époques suivantes (fig. 8).

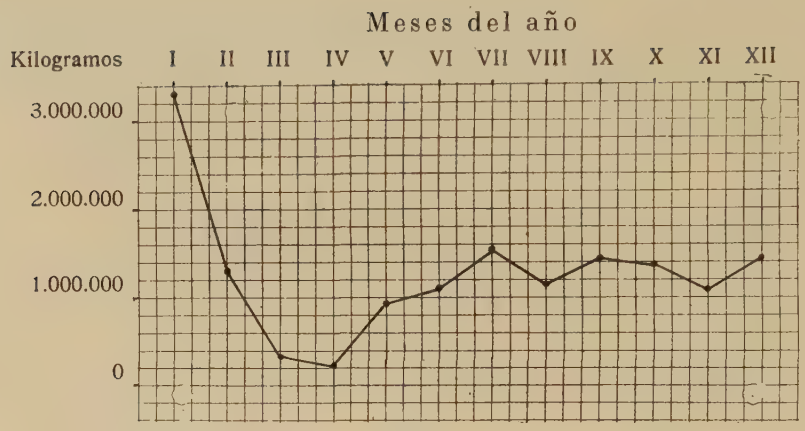


Fig. 6. Pêche débarquée à Santander pendant les années 1919 à 1928.

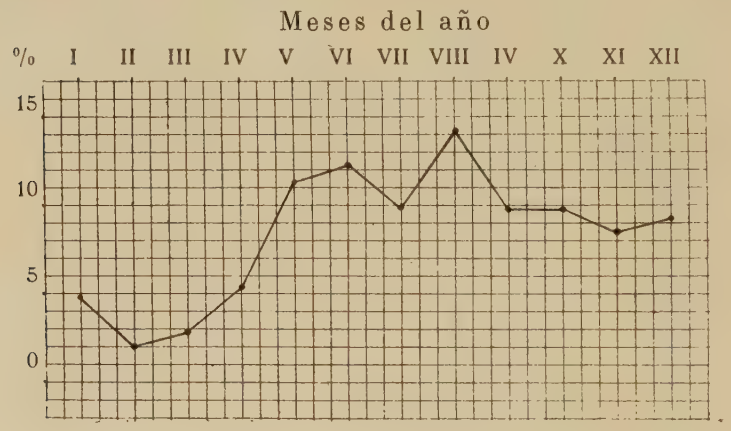


Fig. 7. Pourcentage de la pêche de la sardine à Vigo (NW. d'Espagne) pendant les années 1906 à 1915.

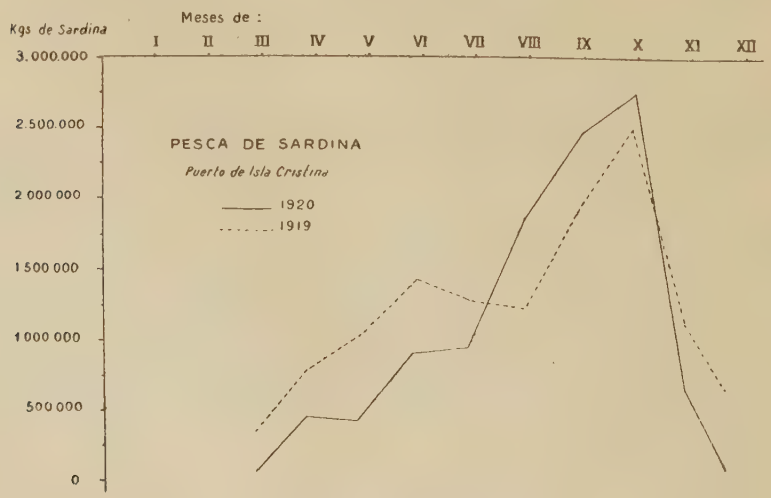


Fig. 8. Sardine débarquée à Isla Cristina (Mer d'Espagne) pendant les années 1919 et 1920.

En considérant le problème dans ses phases générales, nous pouvons nous rendre compte parfaitement de la répartition mensuelle de la pêche de la sardine dans la Péninsule Ibérique.

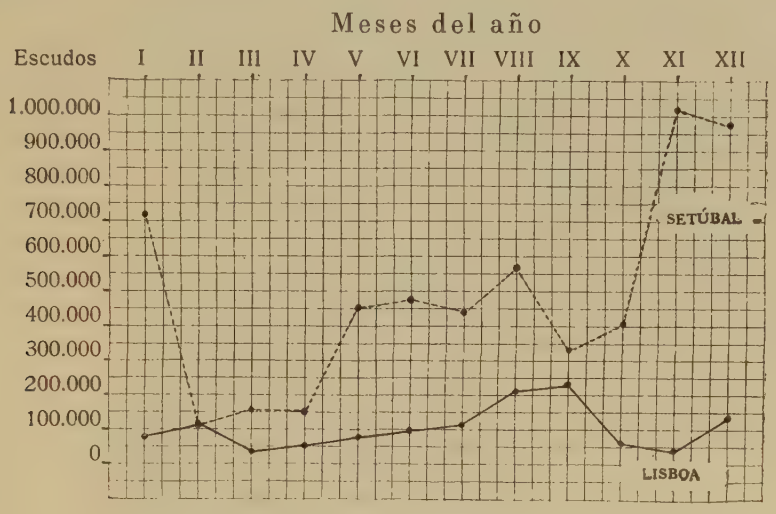


Fig. 9. Fluctuation de la pêche de la sardine en 1920. Ports de Lisboa et Setúbal.

Fig. 10. Fluctuation mensuelle de la pêche de la sardine en 1920. Ports d'Aveiro y Leixões.

Pendant toute l'année la pêche se pratique sur les côtes, cependant, il y a des régions privilégiées par leur grande richesse hivernale. A cet égard, les graphiques correspondant à Santander (figure 6) et à Sétubal (fig. 9) sont typiques.

En nous éloignant de ces centres d'abondance hivernale, nous observons dans des ports relativement proches une plus grande abondance estivale (fig. 10, de Aveiro), qui successivement s'étend aussi à l'automne (fig. 8, de l'Ile Cristine).

Le type intermédiaire entre le maximum de la pêche de l'hiver et de l'automne correspond à d'autres ports (fig. 7, de Vigo, et figure 11, de Olhão et Portimão).

Si nous observons la limite de ce déplacement d'abondances, nous découvrons une coïncidence remarquable avec l'invasion géographique de chaque race. Par exemple, la nommée race atlantique méridionale abonda en hiver en 1920 à Sétubal, et en été plus au Nord, à Aveiro, et plus au Sud, à Olhão, marquant les limites sur la côte espagnole, à Vigo d'un côte, et Isla Cristina du côte opposé, avec tendence visible, surtout dans ce dernier port, pour la pêche automnale.

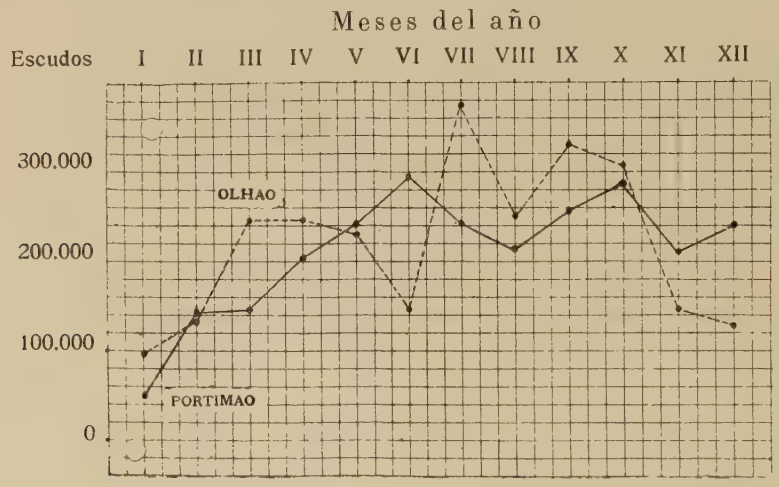


Fig. 11. Fluctuation mensuelle de la pêche de la sardine en 1920. Ports de Villa Nova de Portimão et Olhão.

L'abondance de la sardine, à partir des centres de prédominance hivernale se dirige vers les limites de chaque race, où on peut constater une pêche plus grande en automne.

Il serait de grand intérêt de recueillir des statistiques exactes pour pouvoir généraliser le problème et d'observer son existence aussi sur les côtes de France et d'Angleterre. Nous pourrions, alors, affirmer avec certitude, que la sardine se prête à des concentrations dans des époques determinées, celles-ci formant le centre de dispersion vers les limites de chaque race.

III.—Dans la Péninsule Ibérique, le plus grand nombre d'adultes en état de pondre, en pleine maturité sexuelle, peut s'observer aux époques de cette concentration hivernale. Il est donc probable que la ponte est un facteur prédominant dans ces concentrations et dispersions.

En consultant les statistiques de l'année 1920 et d'autres années, à fin de découvrir les variations qui puissent y exister, nous avons calculé pour chaque port important de la Péninsule Ibérique, sur son littoral atlantique, le pourcentage correspondant

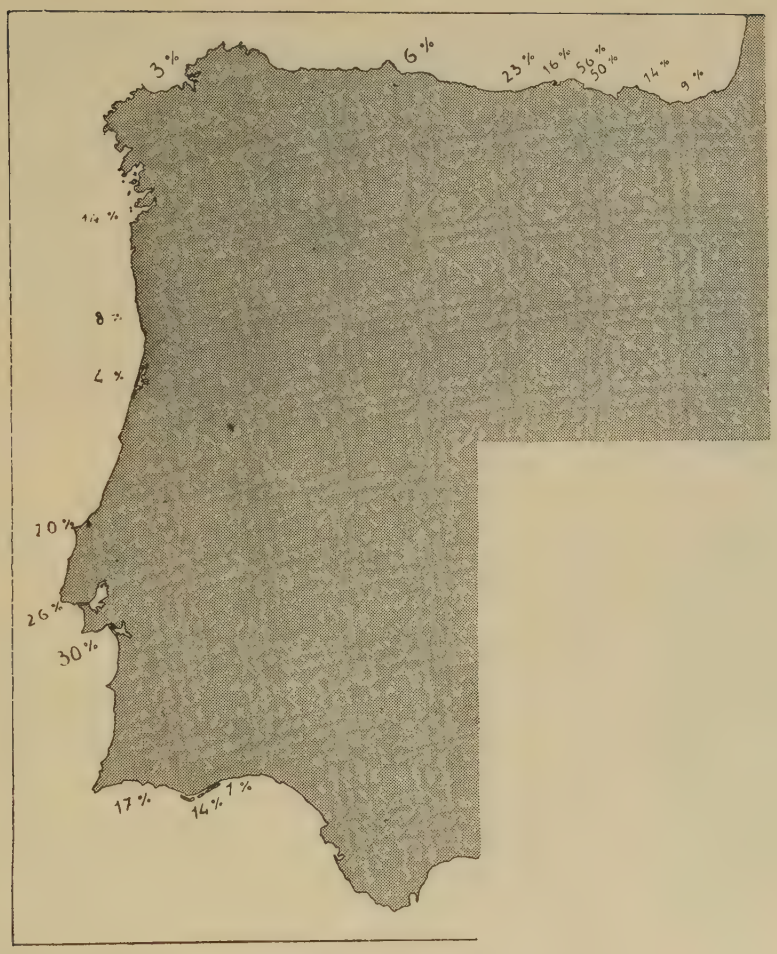


Fig. 12. Pourcentage de la sardine capturée (en kilogrammes pour la côte espagnole, en "escudos" pour la portugaise) pendant les mois de Décembre, Janvier, et Février, par rapport à la totalité de l'année. Année 1920.

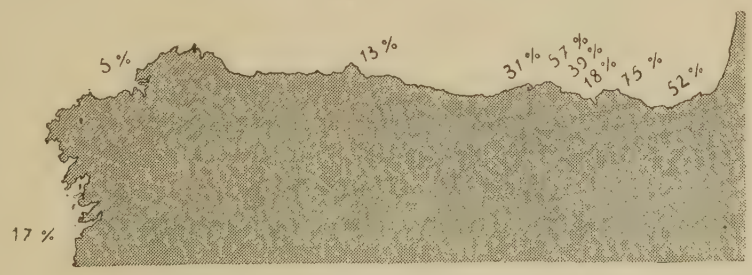


Fig. 13. Sardine capturée (en kilogrammes) dans la côte du N. et NW. d'Espagne pendant les mois de Décembre, Janvier et Février, calculée en pourcentage par rapport à toute l'année. Année 1928.

aux trois mois de décembre-janvier-février, pour le comparer avec la pêche totale de la même année. Les résultats obtenus, bien explicatives (figs. 12, 13 et 14).

Pendant les mois de décembre-janvier-février, le pourcentage maximum de la pêche de la sardine sur les côtes atlantiques de la Péninsule Ibérique correspond au fond de la mer Cantabrique (départements de Biscaye, Santander et quelquefois aussi Guipúzcoa) et aux proximités du fleuve Tage, en Portugal.

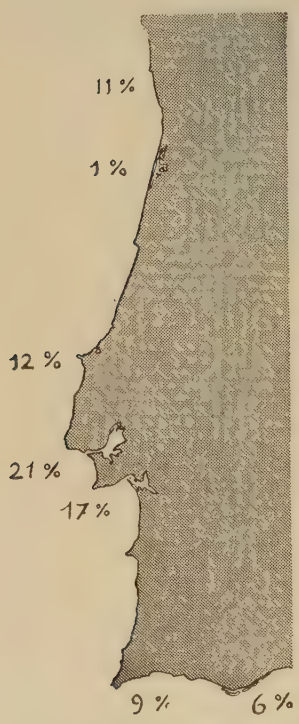


Fig. 14. Sardine débarquée dans quelques ports de la côte de Portugal (valeurs donnés en "escudos") pendant les mois de Décembre, Janvier et Février, comparée avec la totalité de l'année. Année 1924.

De l'un comme de l'autre côté de ces centres hivernaux, la pêche diminue successivement dans ces trois mois de décembre-janvier-février. On constate seulement une petite augmentation dans les "rías bajas" de la Galice (Vigo), et aux ports voisins du Portugal (Leixões).

IV.—La statistique officielle anglaise des années 1887 à 1925 signale une époque de pêche précaire de la sardine entre 1915—1918. Une diminution rapide entre 1904 et 1917 est suivie d'une hausse jusqu'en 1925 (fig. 15).

Si ces oscillations étaient régulières, se répétant périodiquement les maximes et les minimes, l'abondance de 1904 devra se répéter en 1931, en tenant compte de la baisse maxima de 1917. Mais si nous faisons la revision des temps antérieurs, de 1887 à 1903, nous ne voyons pas un minimum très signalé, qui aurait dû se produire vers 1891.

Plutôt que des périodes régulières et répétées dans la série d'années, on observe des périodes avec des caractéristiques déterminées. Ainsi, en Angleterre, de 1887 à 1903, la fluctuation de la pêche conserve une certaine régularité dans ses oscillations, qui se perd depuis 1904 jusqu'à la termination de la statistique, en 1925, avec une baisse sensible dans la pêche de la sardine.

Cependant, sous ce point de vue la statistique française (1894—1902), des côtes atlantiques, est encore plus typique. Après une hausse soudaine vient une baisse sensible (1894—1902), suivie d'une période à tendance d'oscillations moins brusques (1903—1918), qui termine (1919—1927) avec une époque stationnaire (fig. 16).

Plutôt que des tendances à organiser des périodes séculaires dans la pêche de la sardine atlantique de l'Europe, avec des oscillations intermédiaires, également périodiques, mais moins amples, avec tendances aux maximes et aux minimes de première importance, on observe, spécialement dans la statistique française, des changements brusques, qui se compensent après successivement par des oscillations plus régulières.

A ce qu'il paraît, pour des causes d'origine inconnue, mais qui peuvent très bien être liées à la biologie de l'espèce, de la sardine dans ce cas, surviennent des époques de

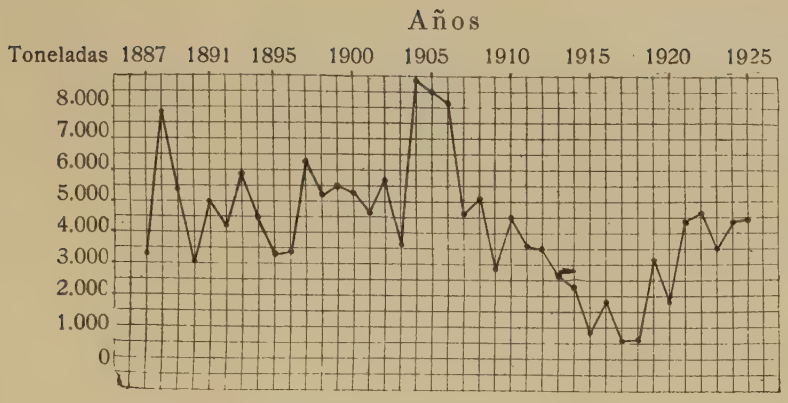


Fig. 15. Sardine débarquée à la côte d'Angleterre pendant les années 1887 à 1925.

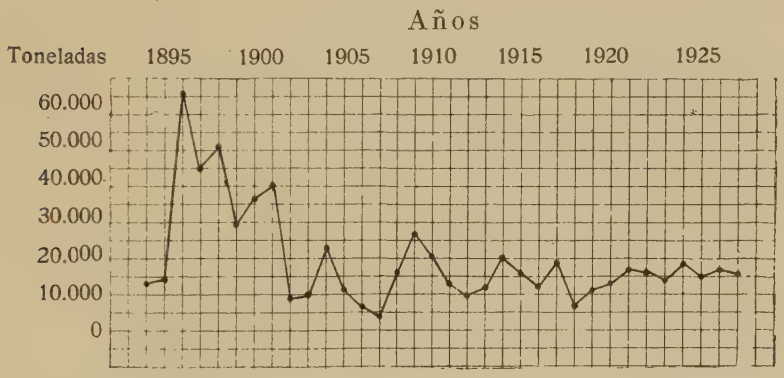


Fig. 16. Sardine débarquée à la côte atlantique de la France pendant les années 1894 à 1927.

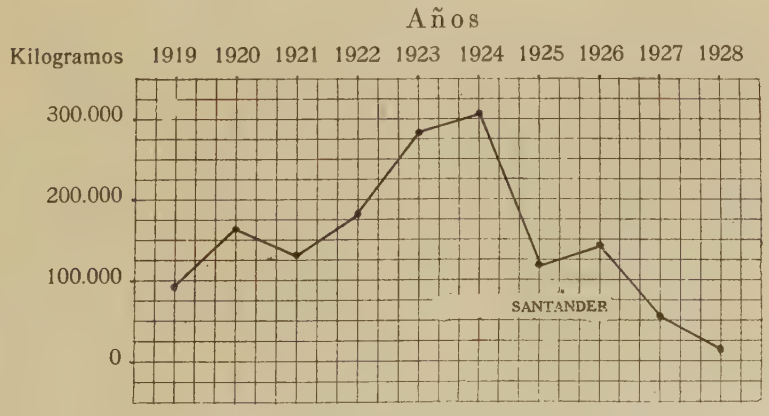


Fig. 17. Pêche débarquée à Santander pendant les années 1919 à 1928.

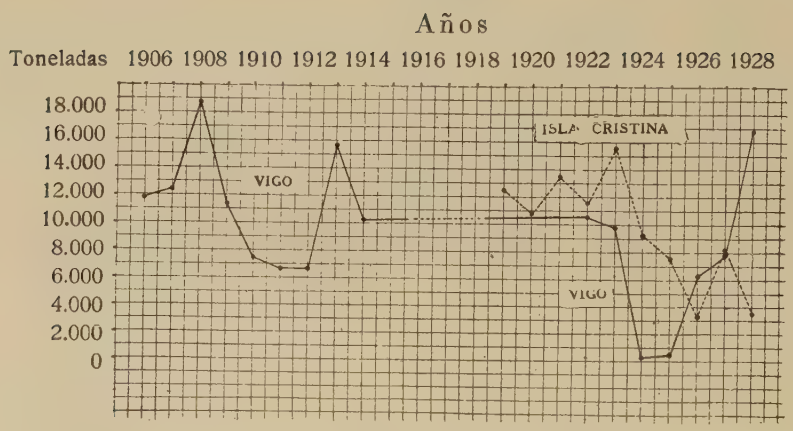


Fig. 18. Pêche débarquée au NW. de l'Espagne (Vigo) pendant les années 1906—1914 et 1922—1928 et à la Mer d'Espagne (Isla Cristina) pendant les années 1919 à 1928.

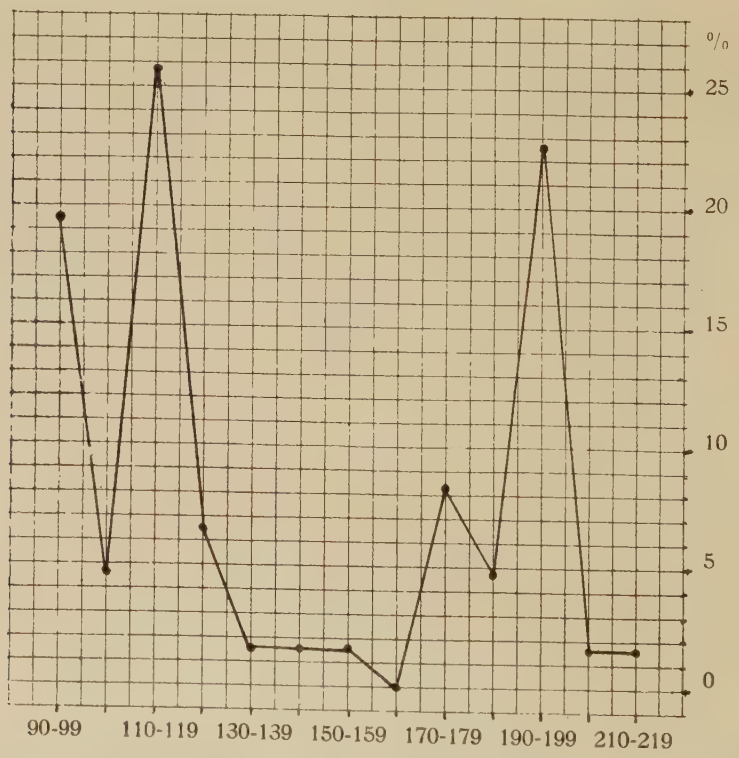


Fig. 19. Polygone de fréquence des sardines de la Mer d'Espagne (Isla Cristina). Septembre de 1916.

prospérité notable, causant un deséquilibre que le reste des êtres qui vivent dans le même milieu, tendent à normaliser. Les premières réactions sont brusques, se font après plus suaves et la normalité s'établit au dernier lieu.

Cet équilibre de la vie en commun parmi beaucoup d'êtres vient à se rompre de nouveau; il surgit une nouvelle abondance de la sardine, et encore une fois se réproduit la série d'époques d'oscillation brusque d'abord et de compensation ensuite.

Il n'existe pas une répétition de ces périodes; il n'y en a pas deux égales, quoique leur existence paraît hors de doute.

Pour expliquer les grandes périodes séculaires jusqu'à présent décrites, on a

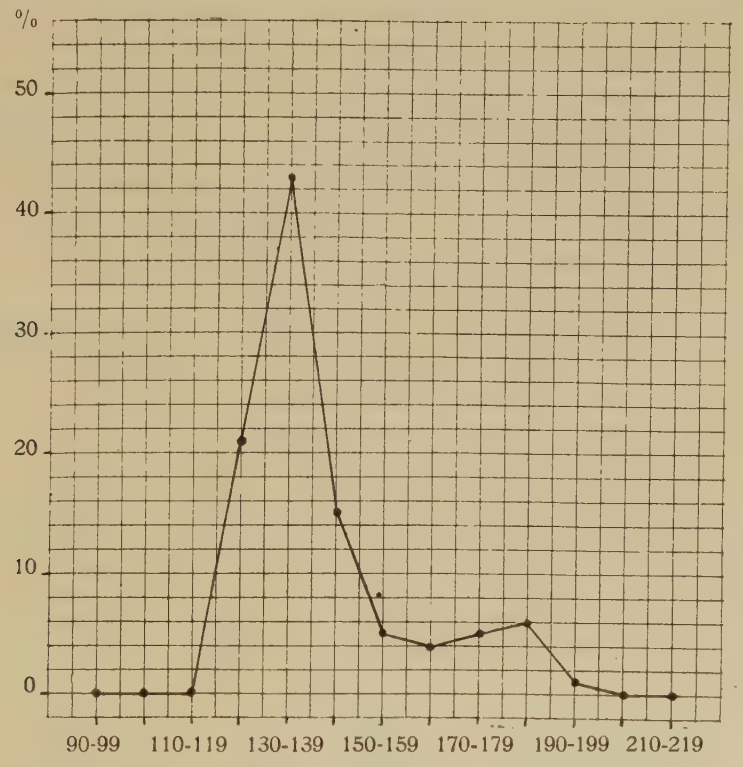


Fig. 20. Polygone de fréquence des sardines de Saint-Jean-de-Luz, tracé avec les données de Paul Arné.

cherché la cause principale dans les variations du milieu marin, influencées par les astres, mais on a exclus un facteur peut-être de la plus grande influence, le facteur biologique, et il faut supposer que cette action est de la plus grande efficacité dans des espèces aussi persécutées comme la sardine et d'une reproduction tellement intense, qui naviguent dans certaines limites en groupes denses, que leurs ennemis et méme l'homme, peuvent décimer. La relation entre la procréation plus ou moins intense, et la destruction par la pêche et les ennemis et parasites, peut très bien être la cause de ces richesses brusques et de ces années de manque sensible de la sardine.

D'autre part, on peut observer que l'oscillation dans la pêche de la sardine ne coïncide pas en comparant les côtes différentes. La statistique française de l'Atlantique suit une loi différente à celle qu'on remarque pour les côtes anglaises, et l'une et l'autre sont différentes de celle du littoral espagnol. Ceci nous affirme dans notre idée; chaque

race a son propre milieu qui lui donna son origine, et la population a ses conditions locales. Les conditions vitales de la vie en commun se montrent de forme différente.

Il y eût en Espagne une crise intense dans la pêche de la sardine, dans les années 1924—1928 (fig. 17 et 18). Elle se fît sentir d'abord au NW. de l'Espagne (1924—1925), et puis au Sud et sur la côte de la mer Cantabrique.

V.—On capture les exemplaires les plus grands de la sardine adulte sur les côtes de la Manche, en face du littoral de l'Angleterre (pilchards), et sur celui de France (celans). Après se font remarquer ces pêches au sud de l'Espagne et en Bretagne.

A Saint-Jean-de-Luz (Mer Cantabrique) et à Isla Cristina (Mer d'Espagne), on signale deux groupes de sardines, celles de taille petite et d'autres plus grandes (figs. 19 et 20). Cependant, cette différence de taille peut avoir son origine, comme déjà nous l'avons fait constater pour Isla Cristina, dans l'engin de pêche employé pour sa capture, ce qui fait qu'aux proximités du littoral on pêche des exemplaires petits, et plus loin de la côte ceux de taille plus grande. Mais quoi qu'il en soit, l'existence de la petite sardine est indubitable.

Pour nous donner compte plus exactement des variations des grandeurs, nous indiquerons, en nous basant sur les chiffres du graphique ou des mesures, comptant les uns et les autres en millimètres, la grandeur plus usuelle, que l'on a observé dans le plus grand numéro d'individus; les classes plus nombreuses:

| | Petites Sardines | Grandes Sardines |
|---|---|---|
| Manche: | | |
| Plymouth | .. | 235—245 |
| Boulogne | .. | 225—235 |
| Bretagne: | | |
| Audierne | 165—175 | 185 —195 |
| Cantabrique: | | |
| Saint-Jean-de-Luz | 130—139 | 180—189 |
| NW. de l'Espagne: | | |
| Vigo | .. | 160—169 |
| Sud de l'Espagne: | | |
| Isla Cristina | 110—119 | 190—199 |

Les chiffres ci-dessus, quoi qu'ils nous donnent une idée de l'ensemble, ne doivent pas être considérés comme définitifs. Il conviendrait de les calculer pendant une série d'années, ou pour le moins pour une année, dans tous les ports, de manière que les différentes catégories de sardines puissent correspondre à de dates similaires.

D'autre part, les sardines qui font l'objet des études, doivent procéder de pêches différentes, surtout sur des côtes où on n'emploit pas la seine, mais des filets flottants dont les mailles sélectionnent la taille des individus.

En somme: les données actuelles permettent d'observer une taille plus petite dans les sardines du NW. de l'Espagne (Vigo) des individus plus grands dans le fond de la

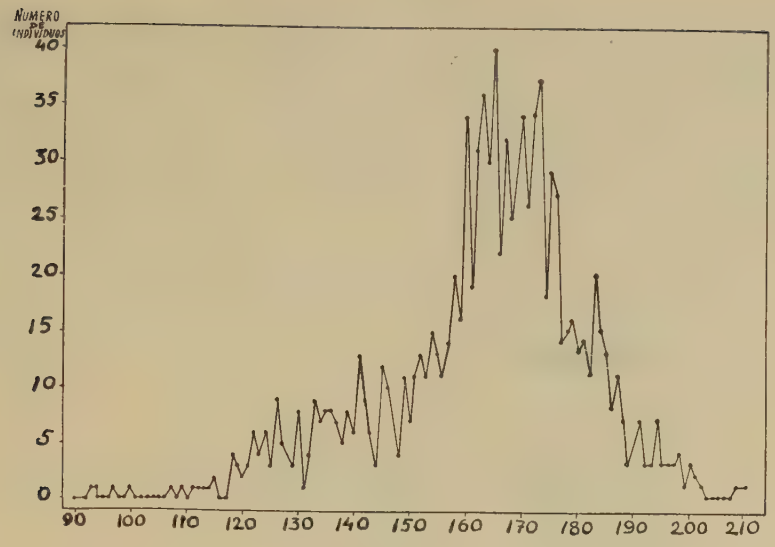


Fig. 21. Polygone de fréquence tracé avec 1.056 sardines mesurées à Vigo.

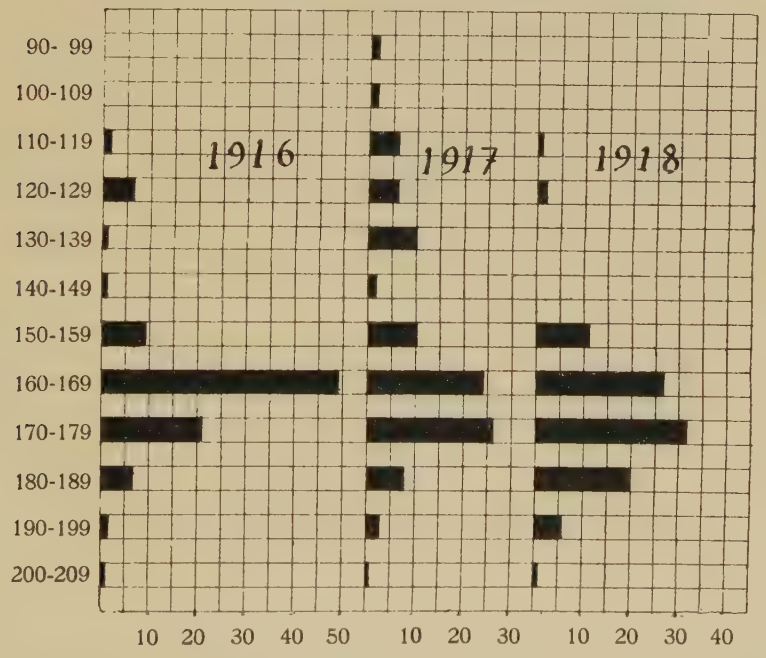


Fig. 22. Comparation de mesures de sardines, prises au mois d'Août de 1916, 1917 et 1918 à Vigo. (Valeurs donnés en pourcentage).

Mer Cantabrique (Saint-Jean-de-Luz), à ceux que suivent les sardines de la Bretagne (Audierne), Sud de l'Espagne (Isla Cristina), alors que ceux de la plus grande taille sont pêchés dans la Manche (Plymouth et Boulogne).

A Saint-Jean-de-Luz et à Isla Cristina apparaissent aussi des petites sardines; de taille inférieure celles du Sud de l'Espagne. L'intensité de cette caractéristique varie sûrement selon les années, dû aux variations des catégories annuelles.

De Vigo nous avons des mesures de 1.056 sardines, (fig. 21). Nous en avons trié celles correspondant aux années 1918 et 1919, en y signalant les mois. En calculant le pourcentage d'individus qui correspond à chaque taille, on observe une variation notable.

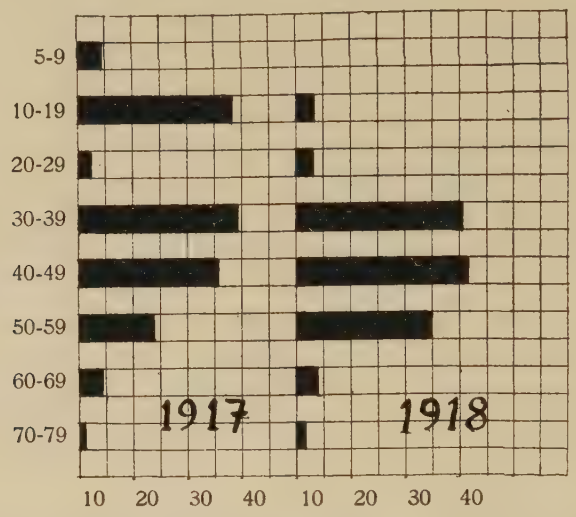


Fig. 23. Comparation des poids de sardines capturées au mois d'Août de 1917 et 1918 à Vigo. (Valeurs donnés en pourcentage).

Vigo-Sardines (Pourcentage).

| | 1918 | | | | | 1919 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | VII | VIII | IX | X | XII | I | II | III | IV | V | VI | VII |
| 90— 99..... | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| 100—109..... | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| 110—119..... | .. | 1 | 2 | .. | .. | .. | 12 | .. | .. | .. | .. | .. |
| 120—129..... | .. | 2 | 2 | 8 | 11 | .. | **28** | 8 | 8 | .. | .. | .. |
| 130—139..... | .. | .. | 4 | 11 | .. | .. | **28** | **37** | 2 | 10 | 2 | .. |
| 140—149..... | .. | .. | 7 | 8 | 7 | .. | 17 | 17 | 7 | 22 | 21 | .. |
| 150—159..... | 3 | 11 | 15 | 8 | 9 | 20 | 5 | 10 | 15 | 22 | 22 | 19 |
| 160—169..... | 29 | 27 | **25** | 19 | 26 | **40** | 5 | 13 | **20** | **23** | **25** | **37** |
| 170—179..... | **41** | **32** | **25** | **24** | **30** | 20 | 5 | 10 | **26** | 16 | 13 | **22** |
| 180—189..... | 25 | 20 | 14 | 11 | 15 | 20 | .. | 5 | 15 | 5 | 12 | 11 |
| 190—199..... | 2 | 6 | 4 | 11 | 2 | .. | .. | .. | 7 | 2 | 4 | 7 |
| 200—209..... | .. | 1 | 1 | .. | .. | .. | .. | .. | .. | .. | 1 | 4 |
| 210—219..... | .. | .. | 1 | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| Nombre de sardines | 61 | 97 | 105 | 37 | 46 | 5 | 18 | 60 | 60 | 137 | 77 | 27 |

Par exemple, dans l'année 1919, au mois de mars, la plus grande quantité des sardines (le 37 pour 100), mesura de 130 à 139 millimètres, alors qu'au mois de juillet le plus grand nombre (aussi le 37 pour 100) était de 160 à 169 millimètres.

Par conséquent, si l'on veut comparer des sardines de différentes années, ou de catégories annuelles, on devra considérer celles de tous les mois, ou tenir en compte les catégories mensuelles, faisant la comparaison, comme nous le pratiquons, entre des sardines mesurées dans les mois identiques d'années successives.

Pendant le mois d'août des années 1916, 1917 et 1918, on observa à Vigo (fig. 22) une augmentation du nombre des sardines les plus grandes. Le nombre très restreint de données dont nous disposons pour établir une comparaison nous empêche d'arriver à des conclusions.

VI.—De la même manière que la longitude, le poids des sardines de Vigo augmente, si nous comparons les individus étudiés pendant le mois d'août en 1917 et 1918 (fig. 23).

# XII. Mortality in the Tribe of Norwegian Herring.

By

**Einar Lea,** Bergen.

## Introduction.

The phenomena of mortality and vitality (to make use of actuarial terms) in a population of herring are so intimately connected with the phenomena embraced by the term fluctuations that a rational study of the last-mentioned group of phenomena cannot be properly executed without giving due regard to the phenomena of living and dying (possibly also of emigration from and immigration into the tribe or population).

For such a study along the lines of vital statistics it has proved necessary, at least for the Norwegian tribe of herring, to include observations from the earliest stages of life, when the prospective herrings are still in ovo or have recently commenced their free life in the sea. It is more than probable that the annual broods of the Norwegian tribe of herring are exposed to very heavy losses during these early stages.

During some hatching-experiments carried out in the spring of 1925 I made the observation that only the superficial layers of herring-eggs, deposited in thick flakes on glass-plates, developed living fry, while the eggs in the deeper layers failed to hatch. Starting from this observation, and keeping in mind the observations made long ago, by Boeck, Buch and others, that herring roe may be found in nature deposited in inch-thick flakes, I succeeded, during the spring of 1928, in discovering that the same phenomenon took place in nature too, perhaps in a more pronounced degree. While nearly all eggs in the flakes found had been fertilised and had commenced hatching, only the embryos in the uppermost eggs were alive and could be brought to liberate themselves. The eggs in the deeper layers, necessarily deposited earlier than the eggs in the superficial layers, contained embryos at very different stages of development, while the bottom-layers were found in a state of putrefaction. During the spring of 1929 similar facts were brought to light.

From this discovery the conclusion follows that the number of fry hatched at the spawning grounds must be relatively independent of the number of eggs deposited (or of the number of spawning female herring) and more dependent on the area covered with eggs. In addition it seems to give a partial explanation of the fact that the numerical strength of a brood of herring is comparatively independent of the mass of parent-herring.

But also when later stages in life are concerned, the study of fluctuations need to be combined with studies on mortality and its complement. If one has, as for instance in the large group of Norwegian spawning herring, to operate only with the relative age-distribution (see fig. 1) it is impossible to carry out anything but crude comparisons with regard to the numerical strength of the several year-classes within the "field of observation", if an assumption concerning the rate of mortality is lacking. By inspection of Fig. 1 (or its correlate, the numerical table), it is possible to conclude with certainty that the year-class 1904 exceeds some other (and younger) year-classes in numerical strength by about thirty times at least. But this estimate, important as it is may be far from the correct one, as no account is taken of the greater losses by mortality suffered by the older year-class.

In order to make comparable the relative values represented graphically in Fig. 1 it is necessary, by means of a knowledge of the rate of mortality, to reduce the values for the several age-classes to a common age, almost exactly as barometric observations have to be reduced to some common level, for instance the mean level of the sea, by means of Newton's formula for the decrease of air-pressure with increasing altitude. How to effect this, is the principal object of this paper.

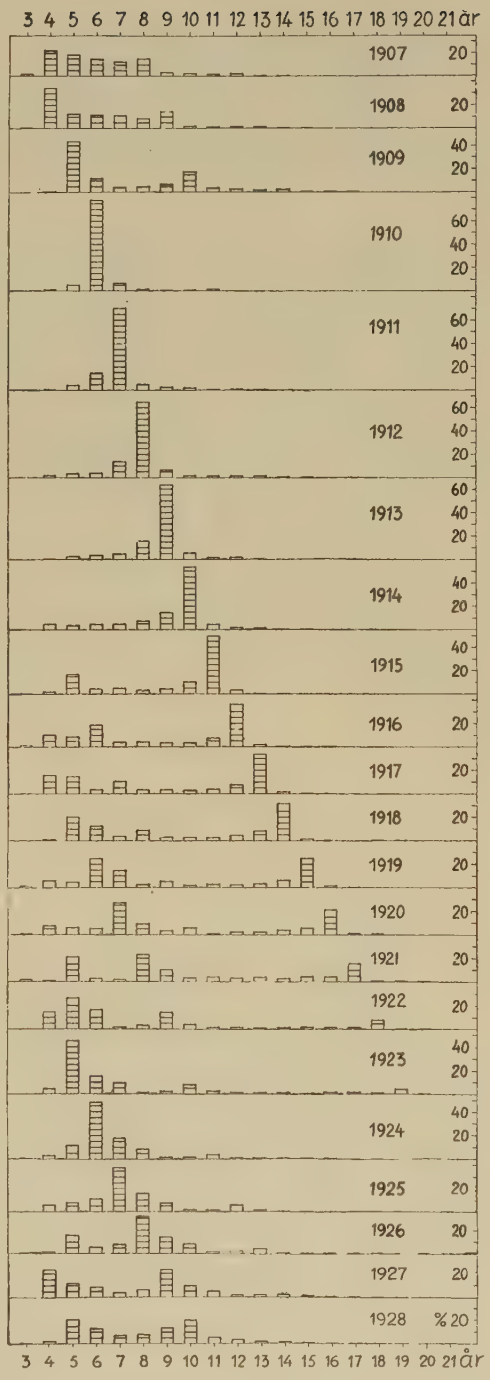


Fig. 1. Age-composition during the seasons from 1907 to 1928 in the stock of Norwegian spawning herring, calculated by combining the samples from each year. The heights in the columns are proportionate to the numerical strengths of the groups, the age of which is indicated by numbers above and below.

## Theoretical treatment.

In a report for 1920 to the then existing Herring Committee of the International Council for the Exploration of the Sea[1]) I included a preliminary account of my work along this line of research. In this account was introduced an algebraic system of notation

[1]) Also in an article in "Naturen", Jan.—Febr. 1927, Bergen.

which, with minor improvements is made use of in the following, as it has proved to be sufficiently convenient.

The main feature of this system is that the letters $a$ and $A$ are reserved for the first year of observation (1907), the letters $b$ and $B$ for the next year and so on. The age-distribution for the first year is not expressed in percents or permilles but per unit, that is, the actual relative numbers will sum up to unity instead of a hundred or a thousand.

When operating with the great group of Norwegian spawning herring, caught during the spring, the youngest age-class represented will in most cases be the class 3 (3 years old herring). The numerical strength of this age-class will be expressed by the term $a_3$, wherein the numeral 3 denotes the age-class, while the letter $a$ denotes the relative number as well as the first year of observation. Similarly $a_4$ will be expressive of the relative numerical strength of the age-class 4 during the same year of observation and so on to $a_n$ for the group of the oldest individuals represented. The sum of all $a$'s ($\Sigma a$) will, by definition, be unity.

Similarly we have for the second year of observation the symbols $b_3$, $b_4 \ldots b_n$ the sum of which is also unity, and so on for the other years.

If we now introduce $A$, $B$ etc. as symbols for the unknown total number of individuals in the whole group considered, the following algebraic table can be written down:

$$\begin{array}{l|l}
a_3 + a_4 \ldots\ldots\ldots\ldots + a_m = \Sigma a = 1 & \Sigma a \cdot A = A \\
b_3 + b_4 + b_5 + \ldots\ldots\ldots + b_n = \Sigma b = 1 & \Sigma b \cdot B = B \\
c_3 + c_4 + c_5 + c_6 + \ldots + c_p = \Sigma c = 1 & \vdots \\
\vdots & \\
n_3 + n_4 + n_5 + \ldots\ldots\ldots n_q = \Sigma n = 1 & \Sigma n \cdot N = N
\end{array} \qquad (1)$$

The left part of this table will then form an algebraic counterpart to the graph in Fig. 1 and to its arithmetical correlate, while the part to the right simply contains the symbols for the unknown total number of individuals in the several years.

Before proceeding with the application of this system it is necessary to emphasise that the group of herring under consideration does not comprise the whole Norwegian tribe, but only a selection, consisting of the mature, spawning fish. This group of spawners will every year receive an addition of young herring, spawning for the first time (recruit-spawners). These recruit-spawners may be of an age of from 3 to 7 years.

The influx of 3 year old recruit-spawners is always rather insignificant, indicating that only very few herrings attain maturity at this young age. The same holds for the 7 year old herrings, but for these the explanation is different, *viz.* that most of the herrings of that age have attained maturity at a younger age. According to the rate of development during the first years of existence (which is indicated by considerable fluctuations in the history of their growth) the main influx of the different year-classes may take

place at an age of 4, 5 or 6 years or even be distributed over two or three of these stages of age. Consequently, when attempting to make a special study of the effect of mortality, it is necessary to exclude the age-groups 3 to 6, as these groups may be affected, later on, by immigration. This does not preclude a similar treatment of these, younger age-classes being of importance in the study of immigration or renewal of the group of spawners, as will be subsequently shown.

It is further necessary not to extend the calculations so far as to include the oldest age-groups, where the amount of material becomes too scarce to give usable results. Finally due regard must be given to the errors in the age-estimates, which will tend to assign too low an age to herrings of an old age and thereby create a spurious and too high a death-rate.

Returning now to the algebraic system it is easy to see that for instance the individuals represented by $a_3$ in the first series belong to the same year-class (are born in the same year) as the individuals represented in the next series by $b_4$ etc., or expressing it generally that individuals represented by $a_n$, $b_{n+1}$, $c_{n+2}$ . . . belong to the same year-class.

Further it is seen that when the members of the series of $a$'s is multiplied by the corresponding letters in the right part of the table, expressing the unknown total number of the group of spawners, the result will be absolute as opposed to relative age-distributions:

$$\begin{aligned} Aa_3 + Aa_4 + \ldots + Aa_m &= A \\ Bb_3 + Bb_4 + \ldots + Bb_n &= B. \end{aligned} \qquad (2)$$

Thus $Aa_m$ denotes all individuals of an age of $m$ years present in the group of spawners in the year $A$, and so on.

Operating at first with those age-classes into which no significant influx of recruit-spawners has taken place (age-class 7, upwards), ratios of the form $Bb_8/Aa_7$, $Bb_9/Aa_8$, or generally $Nn_x/Mm_{x-1}$ can be formed. These ratios are coefficients expressive of the empirical probability that herrings of an age of 7, 8 and $x - 1$ years will survive (or be present in the group) after the lapse of one year.

Of these ratios it can be said beforehand that they must have a numerical value less than unity, as it is assumed that no influx of recruit-spawners has taken place in the interval between the spring of the year $M$ and the spring of the next year, while on the other hand mortality (possibly emigration) will tend to diminish during the interval the total number present in the spring of the year $M$.

These coefficients will be called coefficients of remanence and they will be symbolised by the letter $\varrho$. By means of numerals any particular coefficient may be characterised. Thus $\varrho_{m(x-1)}$ stands for the coefficient $Nn_x/Mm_{x-1}$.

The complement of $\varrho$ is $1 - \varrho$ and may be termed the coefficient of death (possibly disappearance or diminution) and will be symbolised by the letter $\delta$, to which numerals may be added in accordance with the system used for the coefficient $\varrho$.

Thus

$$\varrho_{m(x-1)} = Nn_x/Mm_{x-1} \qquad (3)$$

and

$$\delta_{m(x-1)} = (1 - \varrho_{m(x-1)}) = 1 - Nn_x / Mm_{x-1}. \qquad (4)$$

From these equations it is to be seen that the coefficient $\varrho$ and $\delta$ may be readily calculated, provided the ratios of the type $N/M$ $(B/A, C/B \ldots)$ are known. However, this is not the case in the material considered, and the equations are intended for other purposes, as will presently be explained.

If the series of $\varrho$-coefficients are written down for an interval between two years, for instance the $\varrho_a$'s, in the form to the right in equation (3):

(*a*) $$Bb_4/Aa_3, \quad Bb_5/Aa_4, \quad Bb_6/Aa_5 \ldots$$

and one of them is taken as a standard, then all the other coefficients in the series may be expressed in units of the standard chosen. Taking for instance $\varrho_{a7}$ as the standard we have:

(*b*) $$\frac{Bb_4/Aa_3}{Bb_8/Aa_7}, \quad \frac{Bb_5/Aa_4}{Bb_8/Aa_7} \cdots \frac{Bb_8/Aa_7}{Bb_8/Aa_7} \cdots,$$

which series is equivalent to the following series, wherein all quantities are known:

(*c*) $$\frac{b_4/a_3}{b_8/a_7}, \quad \frac{b_5/a_4}{b_8/a_7} \cdots \frac{b_8/a_7}{b_8/a_7} \cdots$$

This last series (*c*) may serve to ascertain, how the $\varrho$-coefficients alter their value with increasing age and in relation to the standard chosen, provided, of course, that the material of observations is adequate for the purpose. In other words, it is possible to analyse mathematically the form of the rule or law according to which the causes of mortality act upon the individuals of the different ages in the group considered.

The first step in this procedure is to calculate the numerical values of the ratios, the algebraic form of which are given in the series (*c*) above. Out of these calculations will come a series of numerical quantities, one for the interval *A*—*B* (the *A*-series), one for the interval *B*—*C* (*B*-series) and so on.

By inspection of these series, or of the corresponding graph, an impression may be gained with regard to the mathematical connection between the several ratios of $\varrho$-coefficients in the series. As an example the ratios of the *A*-series is given in graphical form in Fig. 2.

In this particular case it will be observed that all ratios, except the first one, practically have the same value as the standard (which is characterised by a double ring). A straight line parallel to the age-axis and through the point expressive of the standard-value (1) will be the most adequate expression for the connection between all the $\varrho$-ratios except the first one.

From this result the following statement follows: all coefficients of remanence ($\varrho$)

and their complements, the coefficients of death ($\delta$) have had the same numerical value in the age-interval between 4 and 15 years. If the standard ($\varrho_{a7}$) had a numerical value of, say 0.7, then all the other coefficients in the said interval would also have this value.

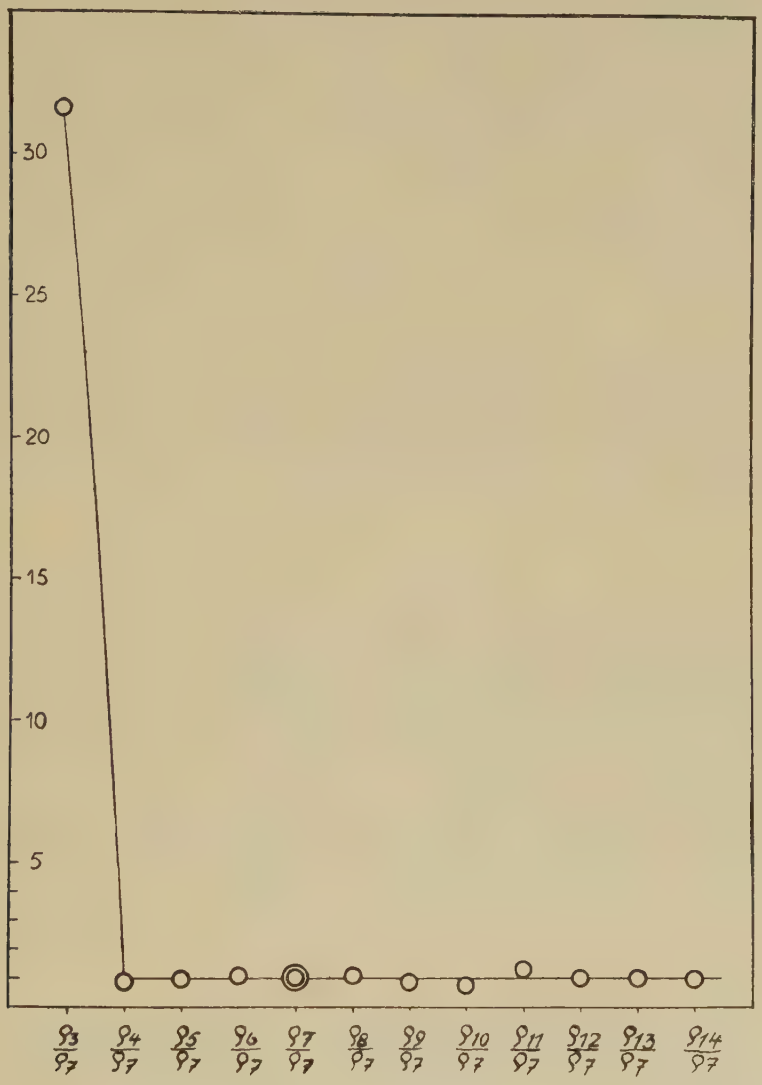


Fig. 2. For Explanation see text.

As this statement also includes the coefficients from $\varrho_{a4}$ onwards, it may be safely concluded that in this particular interval ($A$—$B$) no perceptible immigration of recruit-spawners of the ages 5 to 7 years has taken place.

It is otherwise with the year-class which at the "census-time" in the spring of the year $B$ were 4 years old. Of this year-class a very considerable immigration of recruit-

spawners must have taken place, as is evidenced by the high value of the $\varrho_{a3}$-coefficient. This coefficient in the series cannot be regarded as a coefficient of remanence like the other ones. It is a mixed coefficient, descriptive as well of remanence (from the spring of year *A*) as of immigration. Thus a study of such series of $\varrho$-coefficients may be of service also in the study of other processes than those at issue here, as before mentioned.

A closer scrutiny of all the series of $\varrho$-coefficients calculable from the Norwegian material (up to 1928) has shown that unavoidable errors affect the numerical results to a certain degree, so that it is not advisable to rely on any single series in order to ascertain the connection between the $\varrho$-coefficients. Recourse had to be taken to a calculation of average values.

A lengthy calculation carried out in 1919—20 gave as a result the following equation for the connection between the standard $\varrho$-coefficient $\varrho_7$ and any of the other ones $\varrho_n$ (where $n > 7$):

$$\varrho_n = \varrho_7 (1 - 0.02\, t) \qquad (5)$$

in which equation $t$ denotes the distance in age or time between $\varrho_n$ and $\varrho_7$.

In this equation the numerical value $-0.02$ had a chance-error of $\pm 0.014$ and in addition a systematic error $x$ tending to diminish its value.

Another calculation, where all observations up to 1926 were used gave a similar result:

$$\varrho_n = \varrho_7 (1 - 0.013\, t). \qquad (6)$$

Keeping in mind the errors in age-estimation and taking into consideration the chance-error of the value 0.02 in equation (5) it becomes clear that there is very little, if any, difference between the different $\varrho$-coefficients which are not influenced by immigration of recruit-spawners (the pure remanence-co-efficients) and that they for all practical purposes may be considered as of equal value. This holds, according to the observations for the coefficients between (and including) $\varrho_6$ and $\varrho_{16}$. Therefore the following equation becomes valid for the average conditions prevailing in the Norwegian tribe of herring (excluding the younger stages of age):

$$\varrho_n = \varrho_{st}, \qquad (7)$$

where $n$ stands for any age between 6 or 7 and 17 years.

What value the coefficients would take on for the older age-groups cannot be found, as the material is insufficient for these high ages. Neither is this lack of knowledge of any practical importance, as the year-classes are nearly exhausted at such high ages. But theoretically it would undoubtedly be of interest to know, if the $\varrho$- (and $\delta$-) coefficients remained constant up to still higher ages. For, as far as I can see, the biological interpretation of equation (7) must be that the causes of mortality act with equal intensity on younger and older herring within the limits stated. Compared with the vital statistics for the human population no factor expressive of reduced vitality with increasing age enters the equation (7). The most adequate expression for what is

styled the force of mortality in a human population is the equation formulated by MAKEHAM in the sixties of the last century:

$$-\frac{dy}{y\,dx} = a + kb^x, \tag{8}$$

where $y$ is the number of individuals at the moment considered and $x$ is the time. The expression $kb^x$ will for higher ages attain a more and more dominating value as compared with the constant term a.

For our herring-population the corresponding equation will be

$$-\frac{dy}{y\,dx} = a. \tag{9}$$

This at first rather unsuspected result of the mathematical treatment of the age-observations conforms with our other observations of the herring. Even the very oldest herrings observed have for instance retained their reproductive power, and no signs indicative of senility have as yet been discovered.

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The question may now be put, whether there is any means of determining the numerical value of the coefficients $\varrho$ or $\delta$. A knowledge of these values is *i. a.* very important for all considerations concerning the effects of the fisheries on the population. If $\varrho$ has a large value (and $\delta$ consequently a low value) no fear need be entertained, lest the stock should suffer through overfishing. And further it would be possible by means of observations to follow the fluctuations in the size of the population, as will presently be shown.

For a discussion of this problem it is convenient to consider the equations (2) on page 103. This system of equations can be considered as formal expressions for annually repeated censuses of the particular group of herring, in as much as $A$, $B$, ... are symbols for the total number of individuals present in the different years, while the expressions $Aa_3$, $Aa_4$ ..., $Bb_3$, $Bb_4$ ... denote the total number of individuals in the particular age-classes.

Assuming at first that the total number of individuals is equal at two consecutive "censuses", for instance that $A$ and $B$ are of equal numerical value, then it follows immediately that $A$ and $B$ can be subsistuted for one another in the expressions defining the $\varrho$-coefficients:

$$\frac{Bb_x}{Aa_{x-1}} = \frac{Ab_x}{Aa_{x-1}} = \frac{b_x}{a_{x-1}} = \varrho_{x-1} \tag{10}$$

and, according to equation (7):

$$\varrho_{x-1} = \varrho_n.$$

In this particular case the $\varrho$-coefficient will be calculable from the known relative numbers of the age-distribution.

It will further be seen from equation (10) that when the ratios of the form $B/A$ approximate towards the value of one, then the calculable ratios of the form $b_x/a_{x-1}$ (which may be termed $\varrho'$) will approximate to the real value of the $\varrho$-coefficients.

If on the other hand the $B/A$-values are distinctly or very different from unity, then the $\varrho'$-values will also be distinctly or very different from the true values of the $\varrho$-coefficients according to the following rule: If $B/A$ is greater than unity ($B > A$), then the $\varrho'$-values will be less than the true $\varrho$-values and *vice versa*. This last statement follows from the following reasoning.

The $B$-value, which expresses the total number of individuals in the year $B$, following the year $A$, cannot be greater than $A$-value unless the population considered in the interval between the "census-moments" $A$ and $B$ has received a mass of recruit-spawners which is greater than the mass of individuals lost through mortality during the said interval. But when the relative numbers of recruit-spawners become great, the relative number of older herring must necessarily attain low values, as the total sum (according to equations (1)) is unity by definition. In the case considered ($B > A$) the $b$-member in the ratio $b_x/a_{x-1}$ will be low and consequently:

$$\varrho' < \varrho.$$

The converse case ($B < A$) can happen only when the recruiting during the interval has failed to compensate for the losses through mortality. In which case the relative numbers for the older age-groups will be high, and the ratio $b_x/a_{x-1}$ will be high and consequently:

$$\varrho' > \varrho.$$

In the extreme case that no recruiting at all has taken place, the $\varrho'$-values will be unity, and in the less extreme case that the recruiting has been small in comparison to stock of older individuals, then the $\varrho'$-values will be less than unity but will approach that value.

From this discussion follows that the calculable $\varrho'$-values may be considered as a sort of more or less imperfect or distorted expressions for the true $\varrho$-values. They will, in a fluctuating population, in some cases be lower than the true $\varrho$-values, in other cases higher, and, perhaps, in some cases be nearly identical with them. Thus it becomes reasonable to suppose that when the relative age-distribution has been established for a sufficiently long series of years, it should be possible to arrive at an approximation of the true value of the average $\varrho$-co-efficient, $(\varrho)$, for the population considered.

Before such calculations are carried out, it is, however, necessary to discuss the problem of what difference it will make, when the true $\varrho$-values characteristic for a population have a higher or lower numerical value.

If the $\varrho$-value is high, say 0.9, it is easy to see that the condition, under which the calculable $\varrho'$-value becomes too large as compared with $\varrho$ ($B < A$) will not result in an appreciable difference between the true $\varrho$-value and the calculable $\varrho'$-value.

The condition $B < A$ denotes that the recruiting has not compensated for the losses by mortality, and even in the extreme case that no recruiting at all has taken place the $\varrho'$-values cannot attain a higher value than unity.

On the other hand, when $B > A$ and therefore $\varrho' < \varrho$, the difference between the last two quantities may become very appreciable in cases when the influx of recruit-spawners are very considerable.

Thus it seems that for the particular case considered the $\varrho'$-values may more easily be affected in one direction ($\varrho' < \varrho$) than in the other one, and that average values consequently have a tendency to be too low. But there is good reason to assume that this tendency is partly or wholly counteracted by a greater frequency of the cases, when $\varrho' > \varrho$. If a population, for which $\varrho$ is high, once receives a very considerable influx of recruit-spawners, so that the total number of individuals becomes very great (see Fig. 1 for the year 1910), the immediate result will be that the values for $\varrho'$ are pressed down for the older spawners. But the condition for the population to remain at such a high level as regards the number of individuals is evidently dependant on relative great influxes of recruit-spawners during the following years too. And this is less likely to happen than a moderate or normal recruiting. Therefore it is to be expected that one case of low $\varrho'$-values will be followed by a series of high $\varrho'$-values.

If the $\varrho$-coefficients in a population have a generally low value, say 0.5, then it will be seen that the calculable $\varrho'$-values may be more readily affected in both directions by the influx of recruit-spawners. If the influx during some few years is insufficient, the stock will be rapidly reduced, and the conditions bettered for an augmentation through a moderate influx of recruit-spawners, while on the other hand a great influx, resulting in a large stock, will be rapidly compensated by the high rate of mortality ($\delta = 1 - \varrho = 0.5$). Thus it seems that also for such a population the conditions for calculating an average $\varrho$-coefficient are favorable.

## Results of the Calculations.

According to equation (7) it is permissible, at least for the Norwegian tribe of herring, to consider the several $\varrho$-coefficients from $\varrho_6$ or $\varrho_7$ to $\varrho_{16}$ as of equal value. This circumstance is a very favorable one, when average-calculations are to be carried out. Instead of calculating the average coefficients $\bar{\varrho}_6$, $\bar{\varrho}_7$ etc., each of which will be based upon a minor part of the material available, it becomes possible to make use of the whole material for calculating the average $\varrho$-coefficient ($\bar{\varrho}$) characteristic of the tribe during the period embraced by the observations.

There are of course many ways of combining a system of numerical values to an average. In the case before us one could think of forming the arithmetical average of all values of the many $\varrho'$-values calculable. Another method would consist in forming the ratios of the type

$$\frac{a_8 + b_8 + \ldots + n_8}{a_7 + b_7 + \ldots + n_7}$$

and average the ten numerical values. While the first proposal leads to intricate expressions, the last one is of a rather simple form, and it will, perhaps, be the most natural one in cases, where the fluctuations are comparatively moderate. But it does not work well for the Norwegian tribe of herring, because there will be a sudden and spurious drop in the values obtained, when a very rich year-class is represented in the denominator and unrepresented in the nominator in the ratios mentioned. This complication can be avoided by forming expressions of the type

$$\frac{b_8 + c_8 + \ldots + n_8}{a_7 + b_7 + \ldots + m_7}$$

where the same year-classes are represented in the denominator as in the nominator. The expression above gives an average $\varrho$-coefficient for the age-interval 7 to 8 years ($\bar{\varrho}_7$), and similar expressions can be constructed for the other intervals. But it is also possible to construct an expression of the same type for all intervals concerned:

$$\frac{(b_8 + c_8 + \ldots + n_8) + (b_9 + c_9 + \ldots + n_9) + \ldots + (b_{17} + c_{17} + \ldots + n_{17})}{(a_7 + b_7 + \ldots + m_7) + (a_8 + b_8 + \ldots + m_8) + \ldots + (a_{16} + b_{16} + \ldots + m_{16})}$$

and expressions of this last type are used here for the calculation of the average $\varrho$-coefficient for the Norwegian tribe of herring. The differences in the numerical results by using the different formulas are rather inconsiderable, but it seems that in the last one the many single numbers are "weighted" in a rational manner, which is not the case with some of the other proposals.

Calculations carried out by means of the last formula have given, as might be expected, somewhat different results according to the interval of years embraced. A calculation carried out in 1920 and on the material for the years 1907—1919 resulted in a value of 0.85 for $\bar{\varrho}$. The same value accrued from a calculation embracing the years 1907—1926. By a new calculation for the years 1907—1928 the value found was 0.81. There is reason to assume that this last result is nearest to the truth.

If periods of years are selected, when the stock may be assumed to decrease (for instance the period 1910—1914 after the influx of the rich 1904-class), results may be expected which are too high. The calculation for this period gives a value of the order of 0.9 for $\bar{\varrho}$.

Similar calculations for periods when the stock may be assumed to increase (for instance 1921—1924) may be expected to give too low values. The actual result was of the order 0.7.

Assuming 0.81 as the best value for $\bar{\varrho}$ it becomes possible to construct a part of what may be termed an approximate ideal age-distribution for the group of spawners in the Norwegian tribe of herring, that is an age-distribution, where the effects of the fluctuations in the numerical strength of the different year-classes are eliminated. It may also be considered as an average age-distribution.

The part which can be constructed comprises the age-groups into which no immigration of recruit-spawners takes place (the right branch of the corresponding age-

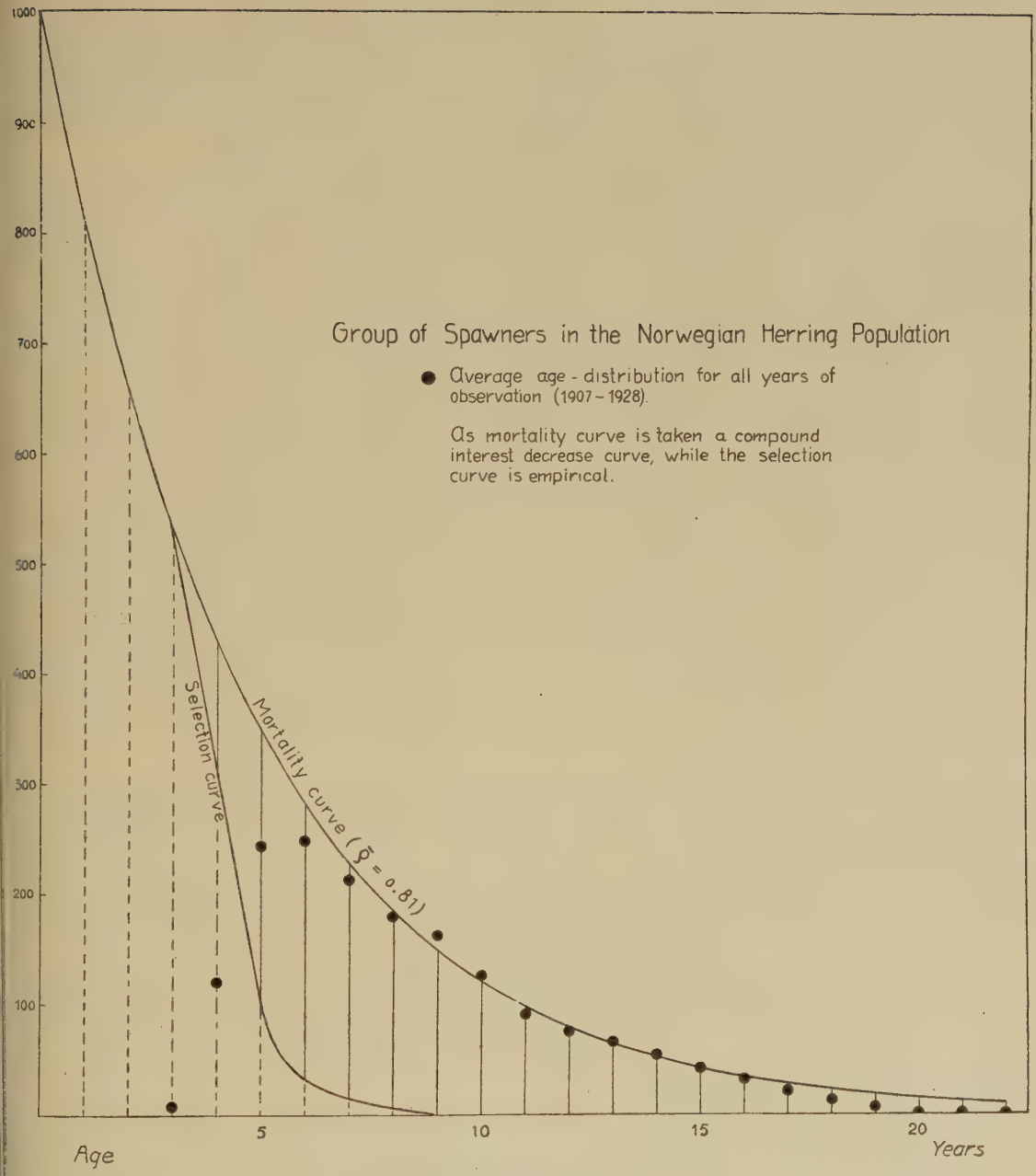


Fig. 3. For Explanation see text.

distribution curve), while the distribution for the age-groups, where immigration takes place must be determined empirically. In Fig. 3 this theoretical age-distribution is shown graphically under the name of "mortality curve". It is in the figure extrapolated backwards to the age of nil, but can, of course, not be expected to hold for the young

ages, as it is based upon the study of the individuals on the age of more than 6 years. Between the limits 7 and 16 years this curve can be said to be in fairly good accordance with the corresponding empirical values represented by black dots, while it goes above the empirical values at the extreme old ages. This is, at least partly, due to the insufficiency of the material of observations.

If the curve may be assumed to hold for the younger individuals (3 to 6 years) actually incorporated in the group of spawners, then some idea can be formed concerning the transfer of the individuals from the stock of immature fish to the group of spawners during the critical ages 3 to 6 years. By comparing the height of the ordinates to the dots (empirical frequency) with the height of the ordinates to the mortality curve (expressing the supposed total number of individuals of the age-groups) it will be seen that of the age-group 3 evidently only a very small fraction is transferred to the group of spawners, while the rest of the age-group is still immature. At the age of 4 years about 28 per cent. of the supposed total number have been included in the group of spawners, at the age of 5 years about 70 per cent. and at the age of 6 years about 88 per cent.

If the difference between the supposed total number of individuals and the number present in the group of spawners is formed for each of the age-groups, and these differences are marked off downwards from the mortality curve along the respective ordinates, then a curve (the selection curve) may be drawn between the points; this curve separates the immature portion of the individuals in the age-groups from the portion which is included in the group of spawners. This selection curve has only a very little importance in the study of a tribe, where violent fluctuations occur with regard to the age at which the individuals attain maturity. But as it may be of use in other cases[1]), it has been included in Fig. 3.

Another application is to make more precise estimates of the relative number of individuals in the different year-classes in the "field of observation". When for instance the year-classes 1905 and 1904 are to be compared the actual relative number for the 1905-class must be multiplied by 0.81 in order to be comparable with the relative number for the year-class 1904 which has in any given year of observation been "exposed to risk" in one year more than the younger year-class.

In this manner the estimates illustrated graphically in Fig. 4 have been made. But in order to facilitate the critical examination of the results, calculations have been carried out, and are included in the figure, for several assumptions concerning the value of $\bar{\varrho}$, or rather of the corresponding value $\bar{\delta} = (1 - \bar{\varrho})$ multiplied by 100, which value may be termed the reduction-percentage.

By an inspection of the five curves, representing as many assumptions concerning the value of $\bar{\varrho}$, it will be observed, that the 1904-class is in all cases the "best" one, and further that the year-classes 1899, 1910, 1913 and 1918 are better than their neighbour-year-classes. Turning to the "bad" year-classes one finds the classes 1907, 1908, 1909, 1914 and 1915 to be poorly represented. As these features are common to a very wide range of assumptions concerning the value of $\bar{\varrho}$ (or $\bar{\delta}$) they may confidently be put down as established facts.

[1]) See Lea: Frequency Curves in Herring Investigation, Report on Norweg. Fishery and Marine Invest. Vol III No. 4, Bergen 1924.

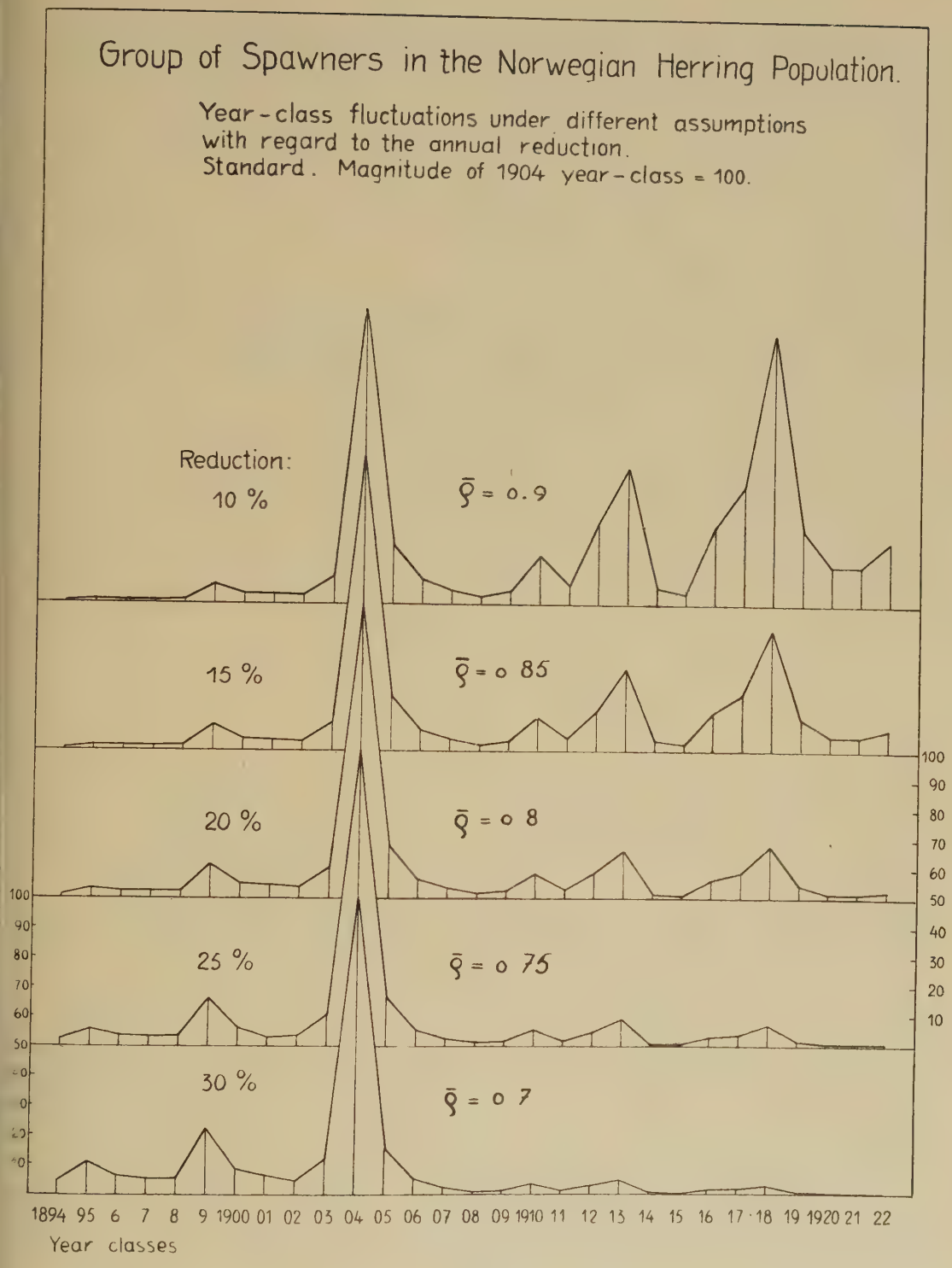


Fig. 4. Fór Explanation see text.

If a comparison is made between the five curves represented, it will be observed that the general trend of the uppermost curve (reduction 10 per cent. or $\bar{\varrho} = 0.9$) goes definitely in the direction of increase in time in the numerical strength of the year-classes. Quite the reverse is the case in the curve at the bottom of the figure (reduction 30 per cent. or $\bar{\varrho} = 0.7$). Something similar, but to a less degree, is found for the two curves which represent the assumptions reduction 15 per cent. and 25 per cent. respectively. Only the third curve from above (reduction 20 per cent. or $\bar{\varrho} = 0.8$) shows no definite trend in either direction, and something very similar would be seen if the curve for $\bar{\varrho} = 0.81$ had been drawn.

The calculated result $\bar{\varrho} = 0.81$ is consequently in accordance with the assumption that the fluctuations in numerical strength of the year-classes are independent of time, while other values of $\bar{\varrho}$ lead to (so it seems to me) the less reasonable consequence that the numerical strength of the year-classes have on the whole been on the increase or decrease during the 29 year-classes under observation.

The third application of the knowledge of the $\bar{\varrho}$-value concerns the estimation of the stock of spawning herring in the different years of observation.

It is not possible to arrive at the absolute number of individuals from observations of the relative age-distributions, but if the mass of spawning herring in one (arbitrary) year is taken as a standard, it should be possible to express the mass or stock in the other years in units of that standard and to obtain a picture of the fluctuations or variations of the stock.

The practical formula to be used for this purpose has the following form:

$$\frac{(a_7 + a_8 + \ldots + a_n)\,\bar{\varrho}}{b_8 + b_9 + \ldots + b_{n+1}} = X = \frac{B}{A}. \qquad (11)$$

This equation follows almost at once from equation (3) on page 103, when it is remembered that $\varrho$ according to equation (7) on page 106 has an equal value from $\varrho_7$ onwards, so that all "older spawners" from the age of 7 years upwards may be treated as one greater group.

In Fig. 5 the results of such calculations are given in graphical form and, as in Fig. 4, for different assumptions with regard to the numerical value of $\bar{\varrho}$.

The most remarkable feature, which is common to all assumptions concerning $\bar{\varrho}$, is the sudden leap in the size of the stock from the year 1909 to 1910, caused by an immense immigration of recruit-spawners of the year-class 1904. This great immigration has caused an augmention of the stock amounting to from more than 10 ($\bar{\varrho} = 0.9$) to 7.5 ($\bar{\varrho} = 0.65$). For $\bar{\varrho} = 0.81$ the augmentation amounts to about 9.5, that is the stock in 1910 is so many times as great as in 1909. During the years following immediately after 1910 there is a decline, as might be expected.

The curve for $\bar{\varrho} = 0.80$ exhibits a downwards slope from 1910 to 1915, followed by an almost imperceptible rise from 1915 to 1916, then a fall to 1918, a rise in 1919, then again a two years fall to 1921, in which year the minimum value after 1909 is reached. From that year there is a gradual rise during the years from 1921 to 1924 caused by an

influx of recruit-spawners belonging to three year-classes (1916, 1917, 1918, see Fig. 1) of which the 1918-class has contributed with more individuals than the two other year-classes taken together. From the maximum-year 1924 there is a slow decline to 1927 followed by quite a slight rise to the year 1928.

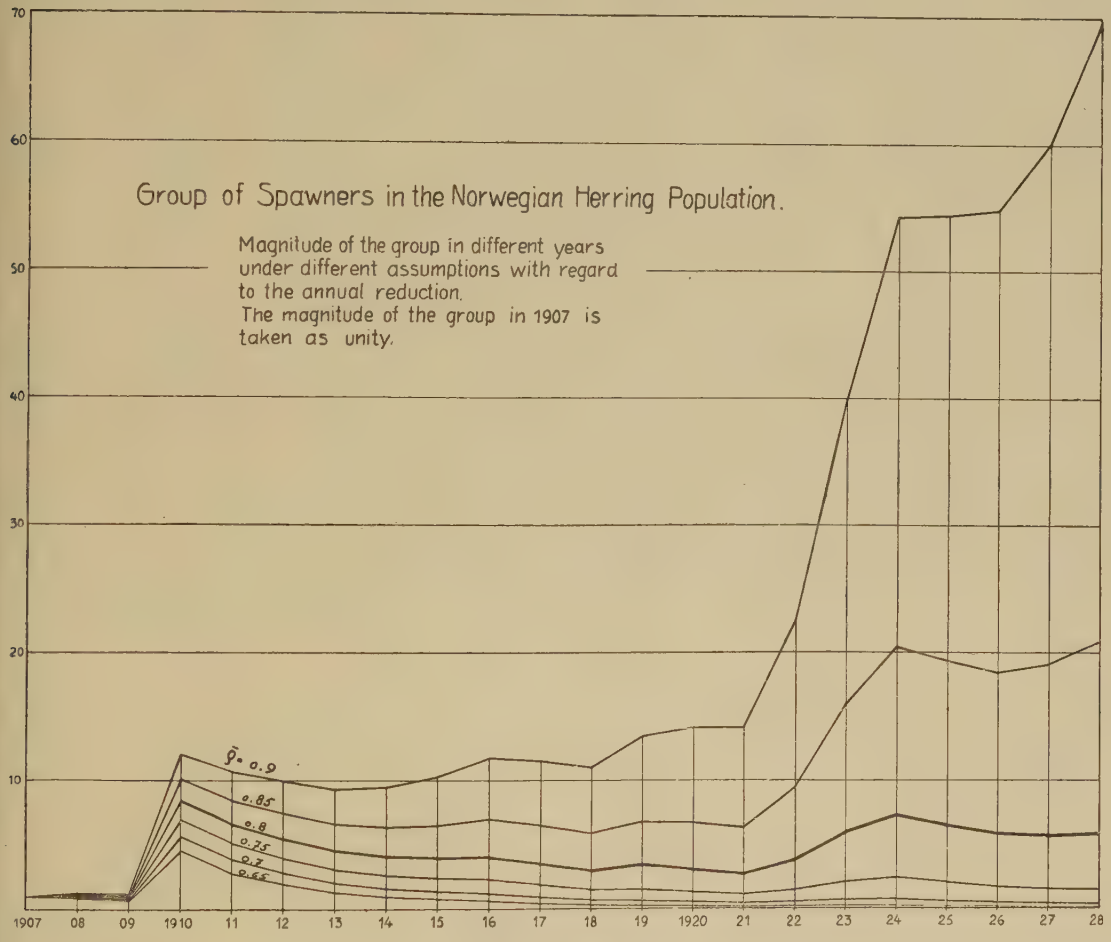


Fig. 5. For Explanation see text.

This curve for $\bar{\varrho} = 0.8$, which goes very close below the curve for $\bar{\varrho} = 0.81$, is favorable to the assumption, that the size of the stock of spawners in the Norwegian tribe of herring was at its greatest height in the year 1910, and that it has never since that year been so small as during the three years preceding that year. As the same conclusion will be arrived at by an inspection of the curve for $\bar{\varrho} = 0.75$, implying a greater reduction, the correctness of this conclusion becomes the more probable.

The curves for $\bar{\varrho} < 0.75$ and $\bar{\varrho} > 0.8$ lead to conclusions which to me appear to be rather improbable. On the one hand ($\bar{\varrho} < 0.75$) they imply that the event in 1910 is quite unique in the "history" of the herring tribe, and on the other hand ($\bar{\varrho} > 0.8$)

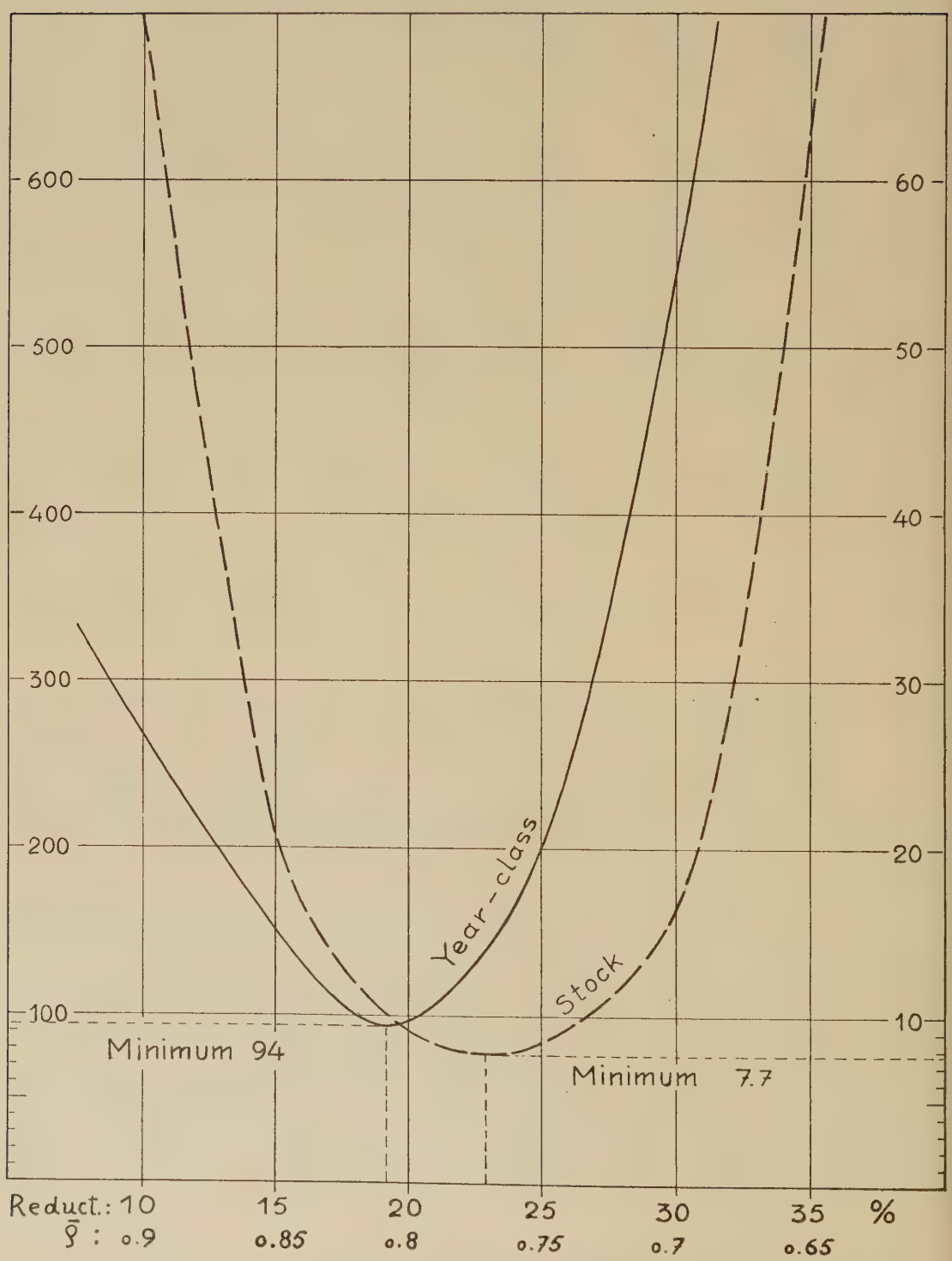


Fig. 6. For Explanation see text.

that the size of the stock has been kept at a very high level during all years since 1910 with a great augmentation during the years 1921 to 1924.

The estimates as to the presumptive value of the different assumptions concerning the value of $\bar{\varrho}$ can be made more acute, if the consequences of the different assumptions are calculated and demonstrated in a graph. In order to do so it is necessary to find a measure for the extent of the fluctuations in the numerical strength of the year-classes and of the fluctuations (or perhaps better the variations) of the size of the stock. A convenient measure is the ratio between the most numerous and the least numerous year-class and the ratio between the greatest stock and the least one under the different assumptions concerning $\bar{\varrho}$.

Such fluctuation ratios have been calculated and are given in graphical form in Fig. 6, where a curve has been drawn connecting the values of the year-class-ratios and one connecting the values of the stock-ratios.

The curve for year-class-fluctuations is seen to have its minimum for a $\bar{\varrho}$-value of almost exactly of 0.81, corresponding to a fluctuation ratio of 94, while the curve for stock-variations lies at a value of $\bar{\varrho}$ of about 0.77 corresponding to a stock ratio of 7.7. The most plausible value found for $\bar{\varrho}$ (0.81) thus implies fluctuations in the numerical strength of the year-classes and variations in the size of the stock which are very near and not far from the possible minimal values. By other assumptions concerning $\bar{\varrho}$ the ratios rapidly rise towards absurd values. Seen on the back ground of these calculations, the year-class fluctuations and the stock-variations in the Norwegian tribe, great as they are found to be, are yet almost the least possible, consistent with the properties of the material of observations.

# XIII. Fluctuations in the Abundance in the Stock of Herring in the Baltic and the Sound.

By

**K. A. Andersson.**

The investigations in this regard have primarily been made off the coast of Sweden. As shown by Dr. Hessle[1]) and myself[2]) there are great fluctuations in the abundance of the year-classes of the autumn-spawning herring in the Baltic and the Sound, causing great fluctuations in the fishing of herring. Thus the year-classes of 1917 and 1918 were abundant in the whole Baltic, while the classes from 1919 to 1923 on the whole were small (Fig. 1). It is true that the year-class of 1922 presented some increase in abundance, only it was not sufficient to cause any noticeable improvement in the fishing. On the other hand, the year-class of 1924 was relatively abundant both in the Baltic and in the Sound, and consequently the fishing improved during 1927 and 1928. The year-classes of 1917 and 1918 lasted longer in the northern parts of the Baltic than in the southern. In 1926 they had totally disappeared in the southern areas, i.e. at the coasts of the Bornholm Deep, but were found to be still existing in the middle Baltic and played an important part in the Botten Sea.

The rich year-class of 1924 is very prominent among the catches off the coast of the middle and southernmost parts of the Baltic and in the Sound, and seems to be the most abundant on the south coast and in the Sound (Fig. 2). It even predominates in the catches from the Kattegat where it has improved the fishing (Fig. 3). It has moreover commenced asserting itself in the Botten Sea, although not as strongly as farther southward.

Thus these changes in the abundance in the year-classes of the herring appear over large areas, in one year along the whole south and east coast of Sweden, in another in an area including the Kattegat, the Sound, and the Baltic along the Swedish coast. They must consequently result from phenomena in the sea which make themselves felt over extensive areas.

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[1]) Chr. Hessle : The Herrings along the Baltic coast of Sweden, Public. de Circ. No. 89, 1925.
— — : Biological statistics regarding the Baltic autumn-spawning herring. Journ. du Cons. Vol. II, No. 2. 1927.

[2]) K. A. Andersson : Fiskeriundersökningar i Östersjön (Fisheries investigations in the Baltic). Svensk Fiskeritidskrift 1927.

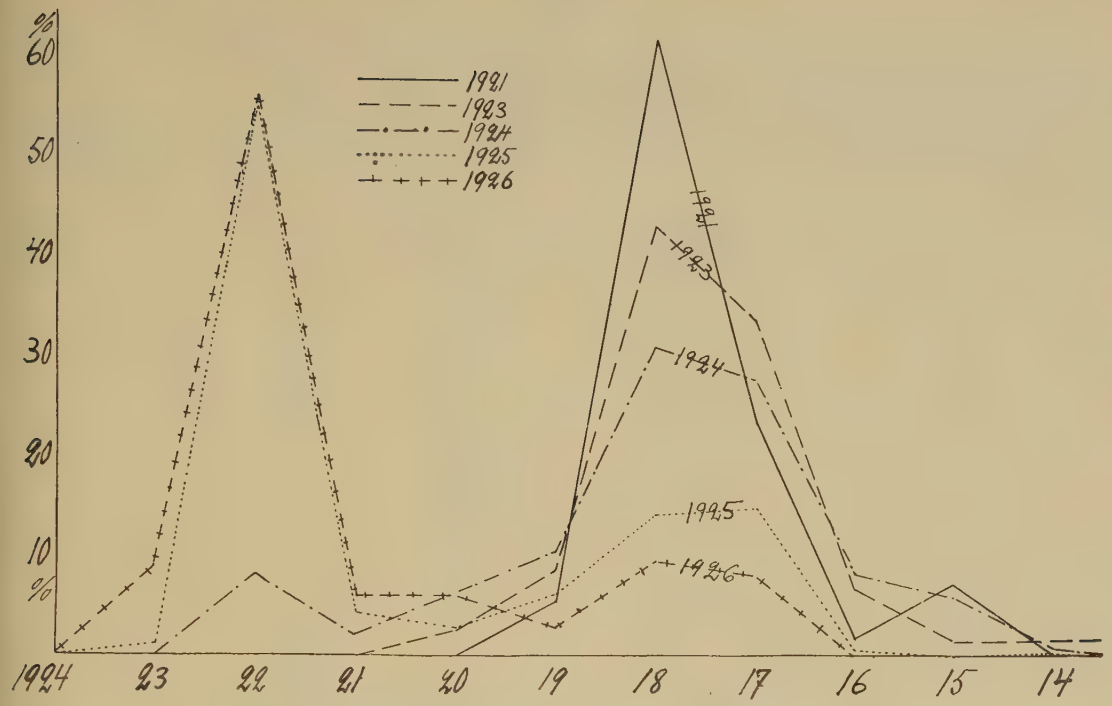


Fig. 1. Baltic autumn-spawning herring. 1921, 1923—26.

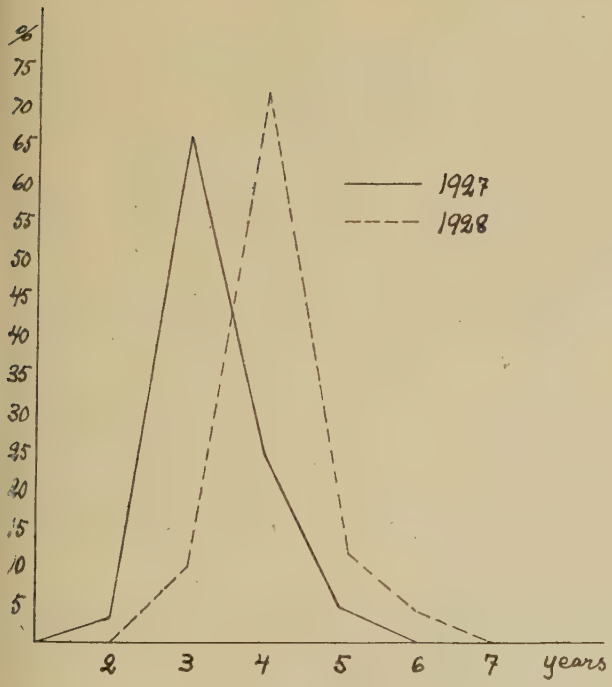


Fig. 2. Age composition of herring catches from the south coast of Sweden. Oct. 1927 and Sept. 1928.

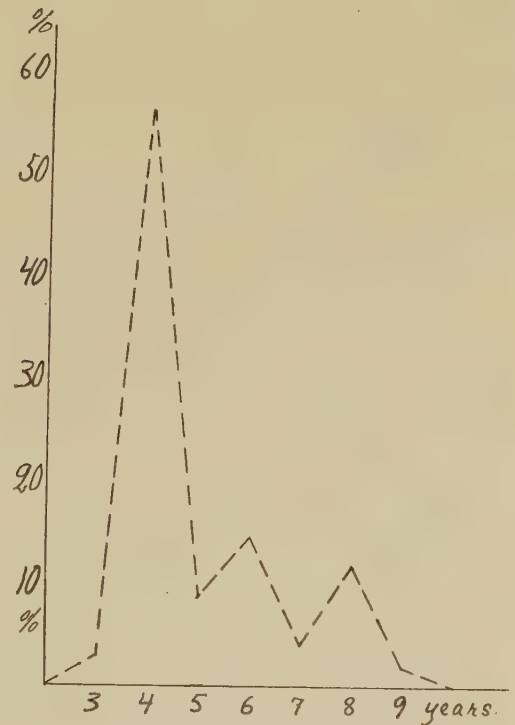


Fig. 3. Age composition of herring catches from Kattegat (Koppargrund and Groves Flak). Oct. and Dec. 1928.

The fluctuations in the year-classes in the Sound and on the south coast of Sweden in the years 1902—1928 need special explanation.

The quantity of herring caught in the Sound and at the south coast of Scania in the years 1902—1928, according to Swedish statistics, may be seen in the following Table:

| Year | Tons | Year | Tons |
|---|---|---|---|
| 1902 | 1117 | 1916 | 7640 |
| 1903 | 326 | 1917 | 7470 |
| 1904 | 904 | 1918 | 5427 |
| 1905 | 1828 | 1919 | 3740 |
| 1906 | 2055 | 1920 | 2972 |
| 1907 | 2394 | 1921 | 2038 |
| 1908 | 1836 | 1922 | 1506 |
| 1909 | 1235 | 1923 | 1112 |
| 1910 | 1005 | 1924 | 577 |
| 1911 | 1733 | 1925 | 845 |
| 1912 | 3871 | 1926 | 835 |
| 1913 | 4707 | 1927 | 2146 |
| 1914 | 1955 | 1928 | 2411 |
| 1915 | 2494 | | |

We see, for instance, that in the year 1916, 13 times as many herrings were caught than in 1924. The average yield of the years of the above mentioned period is 2451 tons. The best year, 1916, exceeded the average yield by 5189 tons, while the poorest year, 1924, was 1874 tons short of it.

From investigations of the abundance of the year-classes of this period, we see that rich year-classes were brought forth in the years 1909, 1913, and 1924. The herrings in question are autumn-spawning and begin to appear in the catches at the age of 3 years when they have their first spawning period and in the Sound an average length of 20 cm. Three years after the origin of the abundant year-classes, the yield is also improved. This was the case in the years 1912, 1916, and 1927 which is in good agreement with the above mentioned statistics. In the year 1903, a good year-class was most probably brought forth. No investigation was made on this year-class, but the improved fishing in 1906 and 1907 speaks for this supposition. Investigations of the proportion of year-classes in the Kattegat have proved that the year-class of 1903 was abundant in the autumn-spawning herring there.

In Fig. 4 the proportion of the year-classes in the catches of 1920 in the Sound and at the south coast of Scania is shown. The then 7-years old year-class from 1913 is still predominant in the catches. Fig. 2 shows that the year-class of 1924 constituted the main part of the catches at the south coast of Sweden in 1927 and 1928 when it was respectively three or four years old.

From an examination of the above mentioned statistics of the fishing at the coast of Scania it at once becomes evident that rich year-classes are by far not always brought forth when the catches are abundant and a great many herrings propagate. Thus the unusually rich fishing in the year 1916 only resulted in a rather poor year-class. During

the years 1917 and 1918 with abundant catches some better year-classes were brought forth, but at the coast of Scania these latter were not particularly abundant, but conducive of a smaller decrease of the stock in the years 1921—1923 than would otherwise have been the case. The relatively good fishing in the years 1920 and 1921 as yet mainly consisted of the year-class of 1913.

On the other hand, good year-classes may appear when the fishing has been scanty or very poor. Of this the years 1909 and 1924 are good examples. The last men-

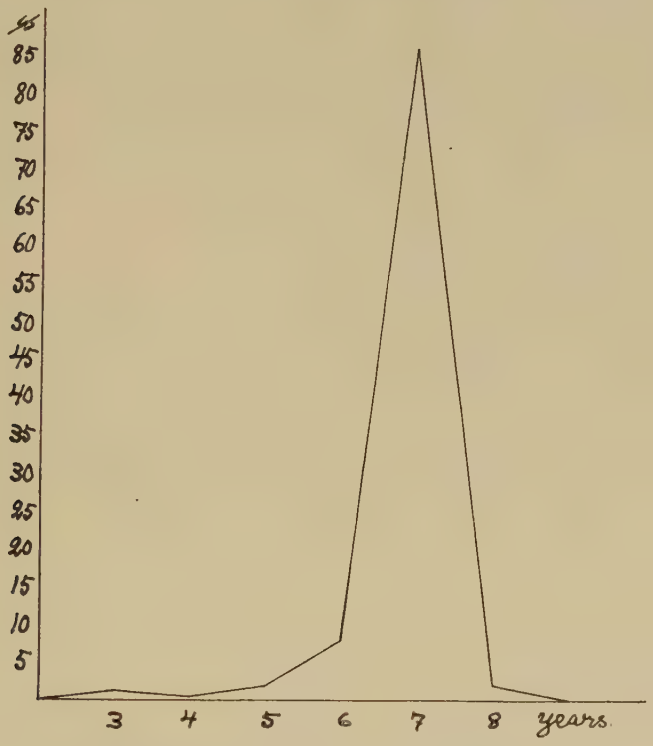


Fig. 4. Age composition of herring catches from the Sound and the south coast of Sweden in the autumn 1920.

tioned year, in which the fishing was the poorest of the last 25 years, indeed resulted in a more abundant year-class at the coast of Scania than any of the years from 1916 to 1918 with their much richer stock of herring.

If, however, favourable conditions inhere, when the fishing is abundant and a great many herrings spawn, then it seems that a still richer year-class may appear. The facts of 1913 are suggestive of this idea. In that year the fishing was far beyond the average and the propagation gave remarkably fine results.

Even till it had an age of 7—8 years this year-class played a prominent part in the catches and had grown from an average length of 20 cm. in 1916 to 26 or 27 cm. in 1920 and 1921, a unique size in the Sound.

From these circumstances the following conclusions may probably be drawn:

Even when the stock of herring is low and the fishing poor, there always seems to be a sufficient number of spawning individuals to bring forth a new abundant year-class, provided that favourable conditions inhere. If, however, conditions that are favourable to the spawning and development of the young inhere, in a year when the fishing is abundant and a great number of herrings spawn, then a still more abundant year-class will be the result.

In this connection I shall point out that the years producing rich year-classes of herring at the coasts of Norway, the Kattegat, the Sound, and the Baltic in certain respects coïncide. Attention must, however, be drawn to the fact that the Norwegian herring spawns in spring, whereas the herring investigated in the Kattegat, the Sound, and the Baltic is autumn-spawning.

The following years had more or less abundant year-classes:

| The Baltic, the Sound, and the Kattegat: | The coast of Norway |
|---|---|
| 1903, autumn (the Kattegat and the Sound) | 1904, spring |
| 1909, autumn (the Kattegat and the Sound) | 1910, — |
| 1913, autumn (the Kattegat and the Sound) | 1913, — |
| 1917 and 1918, autumn (the Sound and the Baltic) | 1918, — |
| 1922, autumn (the Sound and the Baltic) | 1923, — |
| 1924, autumn (the Kattegat, the Sound, the southern and middle Baltic) | 1925, — |

Probably it is not possible as yet to give an explanation of the above named coïncidence, but I have wished to call attention to this fact as it does not seem to be due to mere chance.

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Our knowledge of the causes of the fluctuations in the year-classes is still imperfect. The causes are often ascribed to hydrographical conditions, but we do not know the action of these latter.

Quite by chance I have had an opportunity of observing whether a high temperature is conducive to the developing of a good year-class.

During the autumn of 1925, the temperature of the water in the upper layers in the middle of the Baltic was unusually high, about 2° above normal. It has appeared that the spawning of that autumn did not bring forth a good year-class. This should already have appeared in the catches of the autumn 1928, but has failed to do so.

Thus, in this case a high temperature has not been conducive to the propagation of the herring.

The year of 1924, which gave a good year-class, showed during the spawning time in September, a temperature of the water very close to the mean temperature.

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When is it possible to state that a rich year-class is present? As far as the herring is concerned, it is hardly possible to do so until the year-class appears to be rather pre-

dominant in the catches. And even then we only get a statement of the abundance of the year-class in proportion to the other year-classes in the catches. It cannot be stated with certainty that a year-class is rich until it has resulted in a rich fishing.

The Baltic autumn herring of the year-class of 1922 may serve as an example of this. It was observed that the yields of herring in the Baltic in the years 1925 and 1926 were principally consisting of the old year-classes of 1917 and 1918, and of the year-class of 1922 (Fig. 1). The first named year-classes had on the whole lost very much of their previous importance, especially in the middle and southern parts of the Baltic. As the fishery in this region on the Swedish side in 1925 and 1926 was very poor, it was judged that the year-class from 1922 could not be very strong. For that reason it was not to be expected that the herring fishery in 1927 would be a rich one. In 1927 it was stated that the year-class from 1922 in reality must have been rather poor. It was not at all predominant in the catches of 1927.

If there is no other predominant year-class, a young class, even if poor, can constitute a large part of the stock and of the catches. This was the case with the year-class of 1922 in 1925 and 1926. In 1927 it could hardly be traced in the catches.

In recent years comprehensive investigations have been made, especially by Danish scientists, concerning the occurrence of the fry of the herring in the Kattegat and the Baltic. If these investigations, which have also been taken up by Germans and Swedes, are to be continued for a series of years, we may become able to answer the question whether it is possible from the amount of pelagic young to draw any conclusion as to the abundance or poorness of a year-class. It would evidently be of great interest to be able to know, even from the pelagic stage of a year-class, how abundant it will become in 3 or 4 years' time when appearing in the catches. It is, therefore, of particular importance that the investigation of the quantity of pelagic young of the herring may be continued.

From the time when fluctuations in the year-classes were discovered, particularly through the investigations of J. Hjort, the study of the age of the herrings has constantly gained more practical importance. It may indeed be regarded as certain that it is the fluctuations in the year-classes which are the principal factors of the fluctuations in the fishing, at any rate in the Baltic, the Sound, and the Kattegat. This is, for instance, proved by the above mentioned statistics concerning the catches in the Sound and on the south coast of Scania. Although the abundance of a year-class is only to be determined when it appears in the catches at the age of 3—4 years, these investigations of age may, in certain cases, enable us to predict what the yield of the fishing generally will be. The investigations of age appear to me to present a valuable programme for the future work of the International Council for the Exploration of the Sea.

# XIV. Fluctuations in the Stock of Herrings on the North Coast of Donegal.

By

**G. P. Farran.**

There is, off the North coast of Donegal, an important drift net herring fishery followed by Scottish and Irish boats, working mainly from the port of Buncrana, during January—March and May—June. The landing of herrings during the month of April is prohibited by bye-law, as in that month the fish are spent and do not come into condition till the beginning or sometimes the middle of May.

For the past eight years Mr. Storrow of the Dove Marine Laboratory has been good enough to examine samples of these herrings sent to him by the Irish Free State Fishery Department, and we are indebted to him for details of the age-composition, rate of growth and condition of these samples. From the figures which he has supplied, and which can also be found in the Reports of the Dove Marine Laboratory, I have attempted to make an estimate of the relative sizes of the successive year-classes.

It has been pointed out by Lea[1]) that if an approximately correct mortality or loss factor can be deduced for a stock of herrings it will be possible to estimate the size of the stock in successive years in units of the size of the stock in a given year, and it is on these lines that my estimate is based.

The Buncrana herrings seem to be well fitted for treatment in this way as they apparently consist of a single stock fished for in a well defined area, within a radius of about 30 miles from off the mouth of Lough Swilly, for a limited period. The spawning period is early and short, and not likely to contribute to two successive year-classes, though we do not know whether the herrings from the West coast of Donegal, which seem to spawn in October, may not also make an addition to the stock. (In using the term "year-class" I refer all fish showing one Winter ring in any year to the year-class of the previous year.) The samples, which are caught by drift nets of 32 meshes to the yard, are usually very uniform in any one year, unlike those from the Irish Sea and South coast of Ireland which vary very much in composition even when taken at short intervals in the same locality, and for this reason it is permissible to use a small number of samples, though it would have been better if more had been taken.

[1]) Rapports et Procès-Verbaux (September 1926) XLI.

The following table shows the average percentage composition of the samples examined by Mr. Storrow each year and the average for the whole period, omitting in both cases the fish with two winter rings, as their appearance in the samples is very irregular.

| Winter rings | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1921 (3 samples) | 16.4 | 25.1 | 16.5 | 11.3 | 19.5 | 8.8 | 2.3 | 0.8 | 0.2 | .. |
| 1922 (2 samples) | 6.3 | 26.0 | 22.0 | 20.0 | 6.7 | 13.8 | 3.6 | 1.3 | 0.2 | 0.3 |
| 1923 (2 samples) | 45.5 | 16.0 | 18.6 | 12.4 | 2.3 | 1.3 | 2.6 | 0.6 | 0.6 | .. |
| 1924 (6 samples) | 11.6 | 41.7 | 14.9 | 18.0 | 4.7 | 6.1 | 1.1 | 1.3 | 0.4 | 0.1 |
| 1925 (8 samples) | 9.5 | 21.6 | 40.3 | 5.5 | 14.8 | 3.7 | 2.8 | 1.1 | 0.3 | .. |
| 1926 (3 samples) | 44.2 | 13.6 | 14.7 | 16.4 | 3.6 | 4.1 | 1.0 | 1.8 | 0.2 | .. |
| 1927 (6 samples) | 63.0 | 11.7 | 4.9 | 10.0 | 7.4 | 1.0 | 1.4 | 0.3 | 0.1 | 0.1 |
| 1928 (6 samples) | 25.6 | 52.4 | 11.8 | 4.7 | 2.9 | 1.6 | 0.8 | 0.2 | .. | .. |
| Average | 27.76 | 26.01 | 17.96 | 12.29 | 7.74 | 5.05 | 1.9 | 0.92 | 0.25 | 0.06 |
| Average smoothed on graph | 27.76 | 26.01 | 17.96 | 12.3 | 8.0 | 4.8 | 2.5 | 0.9 | 0.24 | 0.06 |
| Loss per cent. each year | 6.0 | 31.0 | 31.5 | 35.0 | 40.0 | 48.0 | 64.0 | 73.0 | 75.0 | .. |
| Percentage surviving to the following year | 94.0 | 69.0 | 68.5 | 65.0 | 60.0 | 52.0 | 36.0 | 27.0 | 25.0 | .. |

From this table we see that the stock of any year-class decreases at a rate which increases with each year. In its fifth year the loss is 30 per cent., in its twelfth year it is 75 per cent. and by this time the year-class has practically disappeared. We cannot call this a death rate as probably many causes combine to produce the result, natural enemies such as dogfish and hake, fishing, gradual migration to other grounds, perhaps loss of the shoaling habit and, it may be, growth of the older fish to a size too large for the mesh of the nets. Whatever the causes may be, if only they are uniform, they do not affect the validity of the method, which is only concerned with the fish available for capture.

There is no apparent reason why the loss factor of 3 w.r. fish should differ materially from that of 4 and 5 w.r. fish so we may conclude that the remarkably low apparent loss of 6 per cent. is due to a fresh stock of 4 w.r. fish coming on to the fishing grounds and compensating for the real loss. These late arrivals are evidently more slowly growing fish than those which appeared first as 3 w.r. fish, since the size of the 3 w.r. fish, as deduced from the scales of the 4 w.r. fish, is on an average 1.4 cm. less than that of those which first appeared as 3 w.r. fish.

Median size when 3rd Winter ring is formed.

| Year-class | From scales of 3 w. r. fish (January to March) | From scales of 4 w. r. fish |
|---|---|---|
| 1920 | 25.91 | 24.91 |
| 1921 | 25.50 | 23.54 |
| 1922 | 26.48 | 25.01 |
| 1923 | 25.02 | 24.40 |
| 1924 | 26.43 | 24.54 |

Assuming now that the loss factor for each year given above is approximately correct and taking the stock of the year 1921, reckoned as 100, as our starting point, we may infer that in 1922 the stock will have been reduced to:—

94 per cent of 16.4 = 15.4
69 - - - 25.1 = 17.3
68.5 - - - 16.5 = 11.3
65 - - - 11.3 = 7.3
60 - - - 19.5 = 11.7
52 - - - 8.8 = 4.6
36 - - - 2.3 = 0.8
27 - - - 0.8 = 0.2
25 - - - 0.2 = 0.05

or, summing up, to 68.6 per cent. of the stock of 1921,

and will be increased by the appearance of a new group, the 3 w.r. fish. If we compare these figures with the distribution of the 4 to 12 w.r. fish actually found in the 1922 samples we see that although there is a general correspondence there is not an exact agreement. This may be due to errors in sampling either in 1921 or 1922, to abnormal migration out of the area of one or more of the year-classes present in 1921 or to additions to one or more of the year-classes of 1922 by migration into the area. As with our present knowledge we cannot say what is the true reason, though errors of sampling would seem in most cases to give a sufficient explanation, we must deal with the discrepancy as best we can and the method I have followed is to assume that the estimate of the total quantity surviving is correct but that the distribution of the year-classes is as shown by the samples of the following year. Now the samples for 1922 show the 3 w.r. fish as 6.3 per cent. and the remainder, 4 to 12 w.r., as 93.7 per cent. This 93.7 per cent. taking the 1921 stock as 100, will represent 68.6 and the 6.3 per cent. in the same proportion will represent 4.6, making a total of 75.2 as the stock for 1922. We can now divide up this 75.2 in the proportion shown by the 1922 samples getting the following result:—

| winter rings | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| distribution | 4.6 | 19.0 | 16.0 | 14.6 | 4.9 | 10.1 | 2.7 | 1.0 | 0.15 | 0.2 | = 75.2 |

Taking now these figures as representing the 1922 stock, we may in the same way work out the relative sizes of the stock in each year from 1923 to 1928 with the following result:—

| Winter rings | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1921 | 16.4 | 25.1 | 16.5 | 11.3 | 19.5 | 8.8 | 2.3 | 0.8 | 0.2 | .. | = 100.0 |
| 1922 | 4.6 | 19.0 | 16.0 | 14.6 | 4.9 | 10.1 | 2.7 | 1.0 | 0.15 | 0.2 | = 75.2 |
| 1923 | 39.5 | 13.9 | 16.2 | 10.8 | 2.0 | 1.1 | 2.3 | 0.5 | 0.5 | .. | = 86.8 |
| 1924 | 8.9 | 31.8 | 11.4 | 13.8 | 3.6 | 4.7 | 0.9 | 1.0 | 0.3 | 0.08 | = 76.5 |
| 1925 | 5.5 | 12.6 | 23.5 | 3.2 | 8.6 | 2.1 | 1.6 | 0.6 | 1.7 | .. | = 58.0 |
| 1926 | 31.2 | 9.6 | 10.4 | 11.6 | 2.5 | 2.9 | 0.7 | 1.3 | 0.14 | .. | = 70.3 |
| 1927 | 92.3 | 17.1 | 7.2 | 14.7 | 10.8 | 1.5 | 2.1 | 0.4 | 0.15 | 0.15 | = 146.4 |
| 1928 | 41.6 | 85.7 | 19.2 | 7.7 | 4.7 | 2.6 | 1.3 | 0.3 | .. | .. | = 163.1 |

This table read diagonally will give the relative size of each year-class in each successive year and from this we can deduce the initial size of the year-class, making proportionate allowances for the cases in which the earlier or later year-groups are not represented in the record.

Estimated Size of each Year-class.

| Year-class | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | Winter rings | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1914..... | | | ($x = 168$) | | 19.5 | 10.1 | 2.3 | 1.0 | 0.17 | .. | $x + 33.1 =$ | 201.0 |
| 1915..... | | ($x = 47.2$) | | 11.3 | 4.9 | 1.1 | 0.9 | 0.6 | 0.14 | 0.15 | $x + 19.0 =$ | 66.2 |
| 1916..... | ($x = 47$) | | 16.5 | 14.6 | 2.0 | 4.7 | 1.6 | 1.3 | 0.15 | .. | $x + 40.8 =$ | 87.8 |
| 1917..... | ($x = 22.3$) | 25.1 | 16.0 | 10.8 | 3.6 | 2.1 | 0.7 | 0.4 | .. | .. | $x + 58.7 =$ | 81.0 |
| 1918..... | 16.4 | 19.0 | 16.2 | 13.8 | 8.6 | 2.9 | 2.1 | 0.3 | ($x = 0.3$) | | $79.3 + x =$ | 79.6 |
| 1919..... | 4.6 | 13.9 | 11.4 | 3.2 | 2.5 | 1.5 | 1.3 | ($x = 0.5$) | | | $38.4 + x =$ | 38.9 |
| 1920..... | 39.5 | 31.8 | 23.5 | 11.6 | 10.3 | 2.6 | ($x = 4.6$) | | | | $119.8 + x =$ | 124.4 |
| 1921..... | 8.9 | 12.6 | 10.4 | 14.7 | 4.7 | ($x = 4.8$) | | | | | $51.3 + x =$ | 56.1 |
| 1922..... | 5.5 | 9.6 | 7.2 | 7.7 | ($x = 5.7$) | | | | | | $30.0 + x =$ | 35.7 |
| 1923..... | 31.2 | 17.1 | 19.2 | ($x = 27.2$) | | | | | | | $67.5 + x =$ | 94.7 |
| 1924..... | 92.3 | 85.7 | ($x = 154.5$) | | | | | | | | $178.0 + x =$ | 332.5 |
| 1925..... | 41.6 | ($x = 109.0$) | | | | | | | | | $41.6 + x =$ | 150.6 |

The sum of all these successive appearances of a year-class may be taken as representative of its original numbers.

The validity of this method of estimation depends on several assumptions which, at best, are only approximately true. We assume for instance:—

1) that the samples fairly represent the stock on the fishing grounds.
2) that the rate of loss is uniform for each year-class.
3) that the proportion of fish which first appear as 3 winter ringed and 4 winter ringed fish respectively is the same for each year-class.
4) that we are dealing with a single community of herrings of fixed habits.

Apart from the sampling, which is clearly insufficient in some years, the largest source of error probably lies in the difference in the proportion of fish which appear first as 3 winter ringed fish and, as this seems to depend on the size of the fish, we might expect that the more plentiful the food supply was in the preceding two years the larger would be the proportion of fish appearing as three ringed fish.

We can now if necessary revise our loss factors by averaging the estimated figures of loss in each of the year-classes which have been worked out. The averages so obtained give after smoothing a percentage of survival each year of:—

| Winter rings..... | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|
| per cent. surviving to following year..... | 92 | 83 | 72 | 59 | 47 | 39 | 34 | 29 | 24 |

which may perhaps be nearer to the facts than the original figures. In any case by using the new factors we get a result which differs very little from that originally obtained but which is given below for what it is worth.

| Year | Estimated Stock | Year | Estimated Stock |
|---|---|---|---|
| 1921 | 100 | 1925 | 61 |
| 1922 | 73 | 1926 | 75 |
| 1923 | 86 | 1927 | 158 |
| 1924 | 76 | 1928 | 173 |

| Year-class | Estimated Size | Year-class | Estimated Size |
|---|---|---|---|
| 1914 | $x + 32.0 = 232.0$ | 1920 | $123.0 + x = 125.7$ |
| 1915 | $x + 19.0 = 65.5$ | 1921 | $53.9 + x = 57.2$ |
| 1916 | $x + 41.1 = 83.9$ | 1922 | $32.0 + x = 37.1$ |
| 1917 | $x + 58.8 = 79.5$ | 1923 | $72.4 + x = 102.1$ |
| 1918 | $80.0 = 80.0$ | 1924 | $191.0 + x = 375.0$ |
| 1919 | $39.0 + x = 39.3$ | 1925 | $44.2 + x = 170.2$ |

No great weight can of course be attached to these figures of the relative sizes of the year-classes, but at any rate they give us data for a series of years which can be compared with those from other areas.

An attempt to treat the catches from the Irish Sea in the same manner has not so far given a satisfactory result, mainly on account of the want of uniformity in the samples. It would seem that on the East and South coasts of Ireland there is either a greater segregation of the year-classes or else the stock is of composite origin, as samples taken in the same locality may show wide differences in composition in a short space of time.

# XV. Fluctuations in the Herrings of the Southern North Sea.

By

**W. C. Hodgson,** M. Sc.,

Fisheries Laboratory, Lowestoft.

Since the autumn of 1923, observations on the age-composition of the shoals of fish which constitute the great East Anglian fishery, have been carried out annually. The results of these observations are shown in the following table:—

Numbers of growth zones.

| Year | | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1923 | Numbers | 4 | 60 | 491 | 493 | 197 | 93 | 167 | 23 | 9 | .. | 1537 |
| | per cent. | 0.3 | 3.9 | 31.9 | 32.1 | 12.8 | 6.0 | 10.9 | 1.5 | 0.6 | .. | .. |
| 1924 | Numbers | .. | 38 | 220 | 268 | 237 | 74 | 20 | 49 | 7 | .. | 913 |
| | per cent. | .. | 4.2 | 24.1 | 29.3 | 25.9 | 8.1 | 2.2 | 5.4 | 0.8 | .. | .. |
| 1925 | Numbers | .. | 19 | 87 | 110 | 142 | 124 | 17 | 2 | 8 | 1 | 510 |
| | per cent. | .. | 3.7 | 17.1 | 21.6 | 27.8 | 24.3 | 3.3 | 0.4 | 1.6 | 0.2 | .. |
| 1926 | Numbers | 2 | 55 | 430 | 727 | 231 | 187 | 157 | 11 | 2 | 1 | 1803 |
| | per cent. | 0.1 | 3.1 | 23.8 | 40.3 | 12.8 | 10.4 | 8.7 | 0.6 | 0.1 | 0.1 | .. |
| 1927 | Numbers | 10 | 1053 | 379 | 798 | 1160 | 234 | 168 | 38 | 4 | .. | 3844 |
| | per cent. | 0.3 | 27.4 | 9.8 | 20.7 | 30.2 | 6.1 | 4.4 | 1.0 | 0.1 | .. | .. |
| 1928 | Numbers | 1 | 222 | 964 | 135 | 309 | 520 | 95 | 50 | 19 | 3 | 2318 |
| | per cent. | 0.1 | 9.6 | 41.6 | 5.8 | 13.3 | 22.4 | 4.1 | 2.2 | 0.8 | 0.1 | .. |

The numbers of growth zones were counted and not the number of winter-rings and in the following account the term "year-class" includes fish born in the period August—January, thus the 1921 year-class includes herrings born from August 1921 to January 1922. It has been found that autumn spawned herrings do not form a ring on their scales during their first winter, so this method of classification puts all fish with the same number of growth zones into the same year-class.

The following diagram shows the percentage composition of the samples taken during each season.

From the above table and Figure 1 two facts are readily learned. They are (1) the youngest herrings in significant quantities in the shoals are three years old, and (2) the oldest age limit is eleven. It thus appears that the effective life of the southern North Sea herrings is nine years.

In the older year-classes, the proportion which one bears to another is similar for several years, that is, the general outline of the figure remains constant, suggesting that the rate of mortality is acting equally on all the groups of fish.

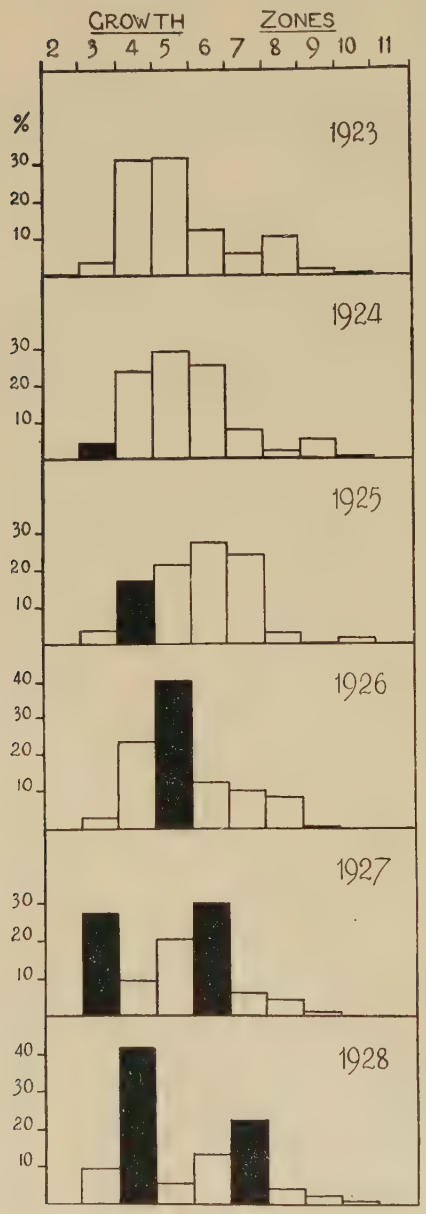


Fig. 1.

During the period under review, there have been five outstanding year-classes.

In 1923, the 1915 year-class was present in such numbers as to form a mode at 8 years, and this group finally disappeared in 1926 when it is was eleven years old. The 1918 and 1919 year-classes formed the bulk of the fishing in 1923, and in 1928 there were still traces of these classes left. These three groups originated before this investigation began, so nothing definite can be said concerning their birth years.

There are, however, two very large year-classes whose birth years occur during the present series of observations, namely, the 1921 and 1924 year-classes. The 1921 class did not appear in large numbers until 1926, when five years old, but after that year, it accounted for the bulk of the larger herrings in the catches, and in 1928 it still formed 22.4 per cent. of the total herrings examined.

From 1923 until 1926, the percentage of three-year old fish in the catches was below 5 in each year, but in 1927 the percentage of new stock suddenly increased to 27.4, indicating that there had probably been a greater addition to the stock than during previous years. In 1928, this addition was further supplemented and the percentage of this 1924 year-class rose to 41.6, the largest proportion of any one year-class which has occurred since the investigation began.

Let us now consider the possible causes of these large year-classes.

In 1921 and 1922 the herring fishery was a comparative failure; the catches were low and the quality of the fish was very poor. They were ill-nourished. It was found[1]) that during these years there occurred in the Northern North Sea, abnormal plankton, and abnormal salt water movement, and in the English Channel, abnormal salt water movements, accompanied by high salinity.

[1]) J. R. Lumby. Fish. Invest. Vol. VII. No. 7. 1925.

A possible explanation of the low catches is, that these abnormal movements of saline water caused the shoals of herring to depart from their usual grounds and thus escape capture. This would mean that there would be many more potential spawners than in a year when heavy catches were made. Another explanation would be, that the hydrographical changes had produced good conditions for the survival of the young brood. In a report which is in preparation, I have shown the connection between the

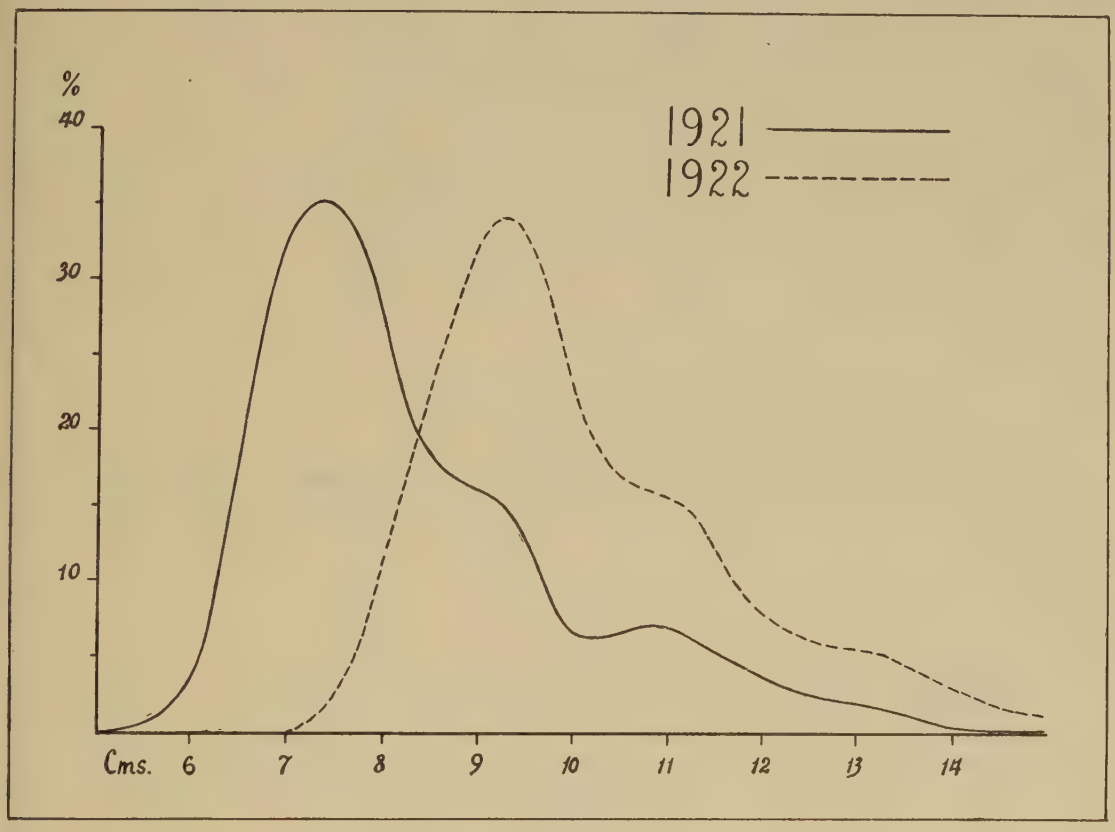


Fig. 2.

whitebait-herrings (0-group) and the calculated length $l_1$, in such a way that it is possible to say with a fair degree of accuracy from which spawning a year-class is derived. The 1921 and 1922 year-classes have been examined for four and three years respectively, and the analyses of the growth calculations point to the fact that the former year-class was composed almost entirely of fish which were spawned in winter (December—January) in the area Sandettie — Cap d'Antifer, and the latter of fish spawned earlier, probably in October—November.

Bearing in mind that a year-class has been assumed to include the autumn spawning of one year and the January spawning of the next, we can say that the 1921 year-class originated mainly in the winter 1921—22, and the 1922 year-class in the autumn (October-

November) 1922. In the diagram above (Fig. 2), the composition of the two year-classes with regard to the length $l_1$, is shown.

In both of these groups, one main spawning has been accentuated in each case, but in the 1924 year-class a different state of affairs is noticed.

In 1927, when the large number of three year old fish was first observed, growth calculations were made on 619 herrings, when it was found that this year-class was made up of two broods, the autumn spawned fish ($l_1 = 10$ cms.) and the summer spawned fish ($l_1 = 12$—13 cms.). The winter broods were not present.

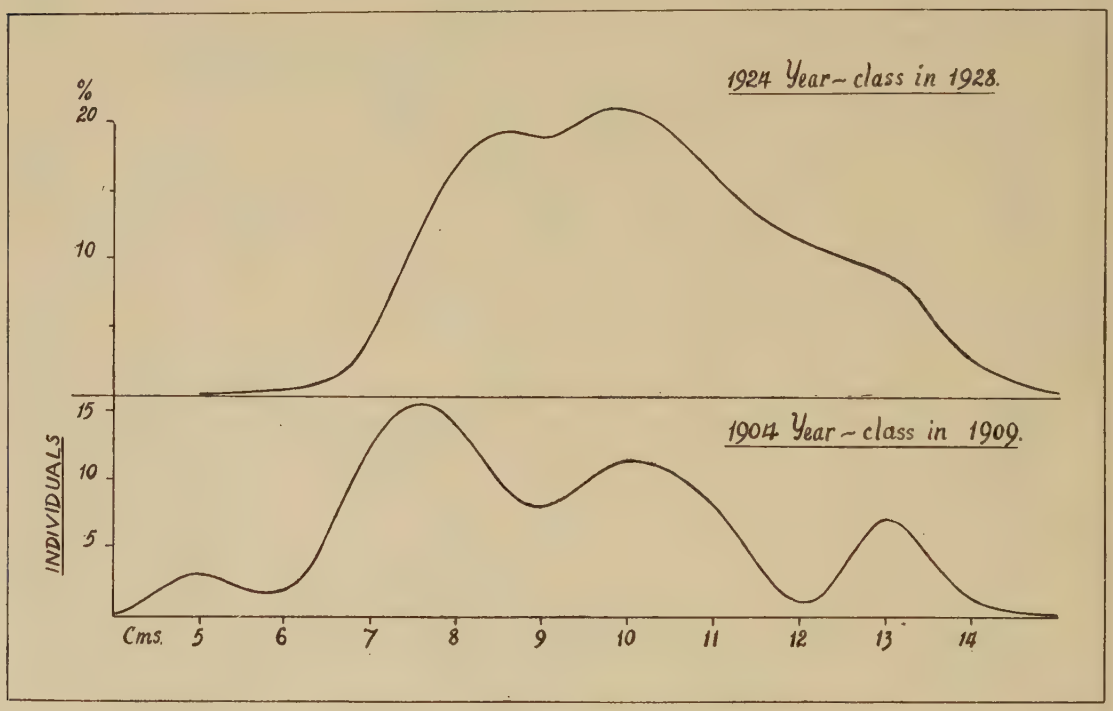


Fig. 3.

The following year, 1928, saw an increase in the percentage of the 1924 year-class (Fig. 1), and 327 herrings (now with four growth zones in their scales) were examined, and the length $l_1$ calculated. The reason for the increase in numbers was now obvious. The fish born in the winter 1924—25 had now joined the year-class and the curve representing the size of $l_1$, became tri-modal. Thus instead of one main spawning supplying the fish of the year-class, we find that conditions were such that the survival of the young of three spawnings has been good.

Above (Fig. 3), I give a diagram showing the length $l_1$ of the 1904 year-class examined by Hjort for Grimsby fish in 1909, compared with the 1924 year-class.

Although only a few fish are used here, the three main broods, 7—8 cms., 10 cms., and 13 cms. are shown. Comparing this with the 1924 year-class, it seems that the good

year-class in each case was due to the good survival of the three main spawnings of the southern North Sea.

The fact that there are three possible spawning times in the southern North Sea leads to difficulties in the classification of the fish by age-groups, because of the difference of age when the first winter-ring is formed on the scales. The winter-born fish are 11—12 months old when their first ring is laid down, the autumn fish are 14—15 months, and the summer spawned fish 16—17 months old.

Supposing the good spawning take place in Summer, Autumn and the following winter, the result will be one large year-class, since all the fish will have the same number of growth zones on their scales. If the winter, summer and following autumn spawning are good, the result will be divided between two year-classes. This is what happened in the 1921 and 1922 year-classes.

It is felt that, while these preliminary remarks on fluctuations may be of interest, the work has not been carried out for a sufficiently long period to allow of more precise conclusions being made.

# XVI. Fluktuationen in der deutschen Trawlheringsfischerei.

Von

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Fluktuation in den Erträgen der verschiedenen Fischereien sind häufig und haben wirtschaftlich grosse Bedeutung. Die Erscheinungsformen dieser Ertragsschwankungen in der Heringsfischerei sind verschieden. Am einfachsten ist wohl die von Jahr zu Jahr wechselnde Ergiebigkeit lang bestehender Fischereien. Wesentlich bedeutsamer in ihrer Auswirkung sind solche Fluktuationen, bei denen die Heringe entweder für eine beschränkte Anzahl von Jahren oder sogar für lange Zeit den gewohnten Fangplätzen in der Nähe der Küste fernbleiben. Für alle diese Arten der Fluktuationen haben wir entsprechende Beispiele in der Nordsee und den ihr benachbarten Gewässern. Da diese Schwankungen offen zu Tage treten und stark auf das Leben der an der Heringsfischerei beteiligten Personen und Gemeinwesen rückwirken, sind vielfach Erklärungsversuche über ihr Zustandekommen gemacht, die aber alle nicht sonderlich befriedigt haben.

Eine andere Art der Fluktuationen ist die von Hjort und seinen Mitarbeitern aufgedeckte Schwankung innerhalb der Schwärme wichtiger Nutzfische nach ihrer Alterszusammensetzung. Sie bietet vielleicht eine Möglichkeit zur Erklärung der jährlichen Schwankungen in den Ausbeuten der Fischerei. In der Tat gelang es Hjort besonders deutlich beim Kabeljau, noch nicht aber beim Hering, den Einfluss dieser Fluktuation auf die Menge der Fische und der Fangerträge nachzuweisen.

Von Deutschland wurde in Verbindung mit der Entwicklung seines Trawlheringsfanges nach dem Kriege das Studium dieser Fischerei aufgenommen unter Benutzung der schon in Norwegen bewährten Methoden. Der deutsche Trawlheringsfang spielt sich von Ende Juli bis Mitte September auf dem Fladengrunde in Wasser von mehr als 120 m Tiefe ab, und von Mitte September bis Anfang November am W- und NW-Rande der Doggerbank auf Wassertiefen von mindestens 60 m. Da der Gegenstand des Fanges eine einheitliche Heringsform, nämlich der Bankhering ist, sollen diese Untersuchungen dazu dienen, mit denen der norwegischen Forscher verglichen zu werden und festzustellen, wie weit die von diesen aufgefundenen Fluktuationserscheinungen auch beim Bankhering auftreten und die Fangerträge bestimmen, oder welche andere Einwirkungen in Verbindung mit ihnen oder allein wirksam sind.

Die Ergebnisse unserer Untersuchungen an Treibnetzheringen sind, soweit es

angängig war, hierbei mit verwertet worden, doch sei daran erinnert, dass bei den im Frühjahr bei Shetland und Orkney und im Winter im Kanaleingange gefangenen Heringen die Zugehörigkeit zu der Formengruppe der Bankheringe z. T. zweifelhaft ist.

Wenden wir uns zunächst den Fluktuationen in der Zusammensetzung der Heringsschwärme nach Jahresklassen zu. Die Grundlage ihrer Feststellung sind Altersbestimmungen aus den Jahren 1922—1928. Der Zeitraum mag kurz erscheinen, genügte jedoch zur Lösung der hier vorliegenden Aufgabe.

Zunächst die Verhältnisse auf dem Fladengrunde.

Im Jahre 1922 ist der Hauptjahrgang 1918 mit 48 % in den Fängen vertreten, daneben der Jahrgang 1919 mit 26 %; die Tiere sind durchschnittlich 23,4 cm lang und 4,2 Jahre alt.

Auch 1923 ist mit einem Anteil von 36 % an den Fängen der nun 5 Jahre alte Jahrgang 1918 am stärksten vertreten, und nach ihm mit 24 % der Jahrgang 1917. Das Durchschnittsalter der Tiere ist 5,8 Jahre, die Länge 25,7 cm.

Ganz ähnlich liegen die Verhältnisse auch noch 1924, in welchem Jahre der Anteil der 1918 geborenen Heringe noch 44 % beträgt, während an zweiter Stelle der Jahrgang 1919 mit 23 % steht. Die Heringe waren nun 25,9 cm lang und hatten ein Alter von 6,0 Jahren.

1925, das als das schlechteste Heringsjahr der Nachkriegszeit gilt, hat sich ein grundlegender Wechsel in der Zusammensetzung der Schwärme vollzogen. Vom Jahrgang 1918, und ebenso von den beiden Jahresklassen 1917 und 1919, ist nicht mehr viel übrig geblieben. An ihre Stelle rückt als wichtigster Jahrgang der von 1921 mit 40 %, und ihm folgt mit einem Anteil von 25 % der Jahrgang 1922. Entsprechend der starken Verjüngung der Bestände ist auch das Durchschnittsalter der gefangenen Heringe auf 4,2 Jahre gesunken und ihre Länge auf 23,6 cm.

1926 ist der Anteil der Jahresklasse 1921 auf rund 50 % gestiegen, und mittlere Länge und Alter der Heringe hat sich auf 24,3 cm und 5,3 Jahre erhöht.

1927 aber tritt der Jahrgang 1921 seine Herrschaft an den schon 1925 zahlreichen Jahrgang 1922 ab, der jetzt einen Anteil von 28 % an den Fängen hat. Neu in Erscheinung tritt die Jahresklasse 1924 mit 22 %. Dieser Beimischung junger Heringe ist es zuzuschreiben, wenn die mittlere Länge der Heringe nur 24,3 cm erreichte und ihr Alter auf 5,2 Jahre sank.

1928 endlich ist der Jahrgang 1922 mit 40 % in den Beständen führend, weitere 17 % der Tiere gehören dem Jahrgang 1924 an. Bei einem Durchschnittsalter von 5,9 Jahren beträgt die Länge der Heringe nun 25,9 cm.

Sehr ähnlich, doch in charakteristischer Weise abweichend stellen sich die Verhältnisse am Rande der Doggerbank dar. Dort überwog im Jahre 1922 der Jahrgang 1918 mit 43 %; ihm nahe kam der Jahrgang 1919 mit 37 %-Anteilen in den Schwärmen. Im ganzen waren die Heringe hier mit einer Durchschnittslänge von 22,4 cm klein, ihr Alter betrug nur 3,9 Jahre.

Im folgenden Jahre (1923) beherrschten immer noch mit einem Anteil von 38 % der Jahrgang 1918, und mit 33 % der von 1919 das Bild. Dem entsprechend ist im Durchschnitte mit 24,2 cm und 4,9 Jahren Länge und Alter der Tiere viel höher als 1922.

1924 dagegen hatte sich die Zusammensetzung der Schwärme dadurch verschoben, dass vom Jahrgang 1918 nur noch 27 % vorhanden ist, dass aber einmalig der Jahrgang 1920 mit 30 % hervorsticht. Die mittlere Länge der Tiere beträgt wieder 24,2 cm, ihr Alter rund 4,8 Jahre.

1925 wiederum ist, genau wie auf dem Fladengrunde, eine ungewöhnlich starke Verjüngung der Bestände erfolgt. Im wesentlichen geschah dies durch den 46 % starken Jahrgang 1921 und den mit 32 % vertretenen Jahrgang 1922. Dadurch fiel die mittlere Länge der gefangenen Tiere auf 22,5 cm und ihr Alter auf 3,9 Jahre.

Auch 1926 und 1927 führten die 1921 geborenen Heringe mit 30 bezw. 26 %, und ihnen folgte an zweiter Stelle der Jahrgang 1922 mit 29 bezw. 23 %. Dazu tauchte 1927 zum ersten Male in erheblicher Menge mit 21 % der Jahrgang 1924 auf. Infolge dieser Entwicklung hob sich auch Länge und Alter der gefangenen Tiere kontinuierlich und stellte sich zuerst auf 23,6 cm und 4,6 Jahre, dann auf 24,1 cm und 5,3 Jahre.

1928 endlich führte mit 44 % der neue Jahrgang 1924, während von der Jahresklasse 1922 nur noch 18 % vorhanden waren. Dadurch wurde zwar das Durchschnittsalter der Heringe auf 4,9 Jahre herabgedrückt, ihre mittlere Länge stieg aber weiter auf 24,5 cm.

Nach diesen Einzeldarstellungen findet man also auf dem Fladengrunde in den Jahren 1922 bis 1924 ein sehr harmonisches Fortschreiten in der Entwicklung der beiden Hauptjahrgänge 1918 und 1919. Erst 1925 wird diese Entwicklung unterbrochen durch eine radikale Verjüngung der Bestände, die das Bild des Jahres 1922 wiederherstellt. Denn hat sich in den drei ersten Jahren der Gipfel der Kurve der Alterszusammensetzung ständig nach rechts verschoben, so rückt er nun wieder nach links. 1926 entspricht dem Jahre 1923; alle Tiere sind, bei gleichem Anteil der einzelnen Jahrgänge an den Beständen um ein Jahr älter geworden, und dem entsprechend rückt der Kurvengipfel wieder um einen Wert nach rechts. 1927 bringt zwar einen Fortschritt dieser Entwicklung, doch ist durch das Auftreten des Jahrganges 1924 die Kurve zweigipfelig geworden. Abgesehen von den durch das Älterwerden der Heringe bedingten Verschiebungen bleibt auch 1928 das Bild dasselbe.

Auf der Doggerbank verlaufen die Alterskurven 1922 und 1923 genau so wie auf dem Fladengrund, 1924 aber wird die Kurve durch das Vorwiegen des Jahrganges 1920 zweigipfelig. 1925 wieder entspricht mit der starken Verjüngung der Bestände den Verhältnissen auf dem Fladen, und dasselbe ist 1926 der Fall, im wesentlichen auch 1927 und 1928, nur dass 1928 auf dem Fladengrunde der Jahrgang 1922, auf der Doggerbank der von 1924 am stärksten vertreten ist.

Die Heringsproben beider Fangplätze zeigen demnach hinsichtlich ihrer Zusammensetzung eine gute Übereinstimmung, und wo diese nicht vorhanden ist, wird der Unterschied durch Eigentümlichkeiten in der Lebensweise des Bankherings bedingt. Der wichtigste Unterschied besteht darin, wie auch Tafel 1 und 2 erkennen lassen, dass auf dem nördlichen Fangplatze nur Heringe gefischt werden, die wenigstens 3 volle Jahre alt sind, also zumeist schon zum ersten Male geschlechtsreif werden, auf dem Dogger dagegen auch, obschon nur in geringen Mengen, 2-jährige unreife Tiere. Daher erfolgt die Ablösung eines guten Jahrganges durch den nächsten, jüngeren auf der Dog-

gerbank ein Jahr früher als auf dem Fladengrunde, wie auch jeder Jahrgang auf dem Dogger ein Jahr früher in den Fängen vertreten ist. Ausserdem ist, im Verhältnis zur Stärke des Hauptjahrganges, der Anteil des folgenden, jüngeren Jahrganges an den Fängen am Rande der Doggerbank ein höherer. Aus allem ergibt sich, dass die auf der Doggerbank gefangenen Heringe im Durchschnitte jünger, also auch kleiner sind als auf dem Fladengrunde. Dies wird auch bewiesen durch die Zusammenstellung der in den Einzelaufführungen gegebenen Längen- und Alterszahlen.

Weiter lässt sich feststellen, und die Tafeln zeigen es, dass beim Bankhering ein guter Jahrgang ungefähr 3 Jahre lang einen ausschlaggebenden Einfluss auf die Zusammensetzung der Schwärme hat, während er, entsprechend der auf 15 Jahre zu veranschlagenden Lebensdauer dieser Heringe, ungefähr 8 Jahre lang deutlich in den Fängen nachweisbar ist. Die Verjüngung der Heringsbestände erfolgt demnach beim Bankhering sehr rasch. In einer normalen Periode hat der ablösende Jahrgang schon vorher eine gewisse Stärke erreicht, um schliesslich den bisher herrschenden älteren Jahrgang zu überflügeln. Die Erneuerung kann jedoch auch so erfolgen, dass plötzlich ein oder zwei neue Jahrgänge auftreten, während der bisher führende ebenso plötzlich verschwindet.

Auch wenn man von dem selbst für norwegische Verhältnisse aussergewöhnlichen Jahrgange 1904 absieht, unterscheiden sich die für den Bankhering gefundenen Werte recht erheblich von den durch Hjort und Lea für den norwegischen Frühjahrshering mitgeteilten. Infolge der längeren Lebensdauer des letzteren, der wenigstens 21 Jahre alt werden kann, ist ein bestimmter Jahrgang 10—15 Jahre hindurch gut in den Fängen nachweisbar und vermag ihre Zusammensetzung ungefähr 6 Jahre lang entscheidend zu beeinflussen. Die Verjüngung der Bestände erfolgt also beim norwegischen Hering entsprechend dem höheren Alter, das er erreicht, bedeutend langsamer.

Eine Übereinstimmung in den guten Laichjahren beider Heringe ist nicht nachweisbar und jedenfalls nicht die Regel; nur einmal war ein Jahrgang für beide Formen zugleich von Bedeutung, und zwar der von 1918, der beim Bankhering von 1922—1924, beim norwegischen von 1923 bis zur Gegenwart dominierte.

Ich habe im Vorhergehenden die Fluktuationen innerhalb der Bestände aufgezeigt und wende mich nun zu den Schwankungen in den Erträgen des deutschen Trawlheringsfanges. Wollte man nur die Kurve seiner Gesamterträge betrachten, so käme man zu unrichtigen Folgerungen. Diese Fischerei war nach dem Kriege im Aufbau begriffen; sie zeigt bis zum Jahre 1924, unabhängig von der Qualität der Saison, ständig steigende Ausbeuten. Erst 1924 wurde ein gewisser Abschluss der Entwicklung erreicht, doch haben auch nach diesem Zeitpunkte wichtige Verbesserungen an den Fanggeräten und dadurch eine Steigerung der Fangausbeuten stattgefunden. Betrachtet man jedoch eine Kurve, die auf Grund der Durchschnittserträge pro Reise eines Fischdampfers entworfen ist (vgl. Figur 3), so sieht man, obschon auch diese Kurve entsprechend der Vervollkommnung der Fangtechnik eine steigende Tendenz hat, dass vor allem zwei Jahre schlechte Erträge lieferten, 1922 und 1925, in geringerem Grade auch 1924 und 1927.

Eine Erklärung für diese Schwankungen lässt sich, z. T. wenigstens, geben, wenn man die von Hjort für die Schwankungen der norwegischen Kabeljaufischerei bei Lo-

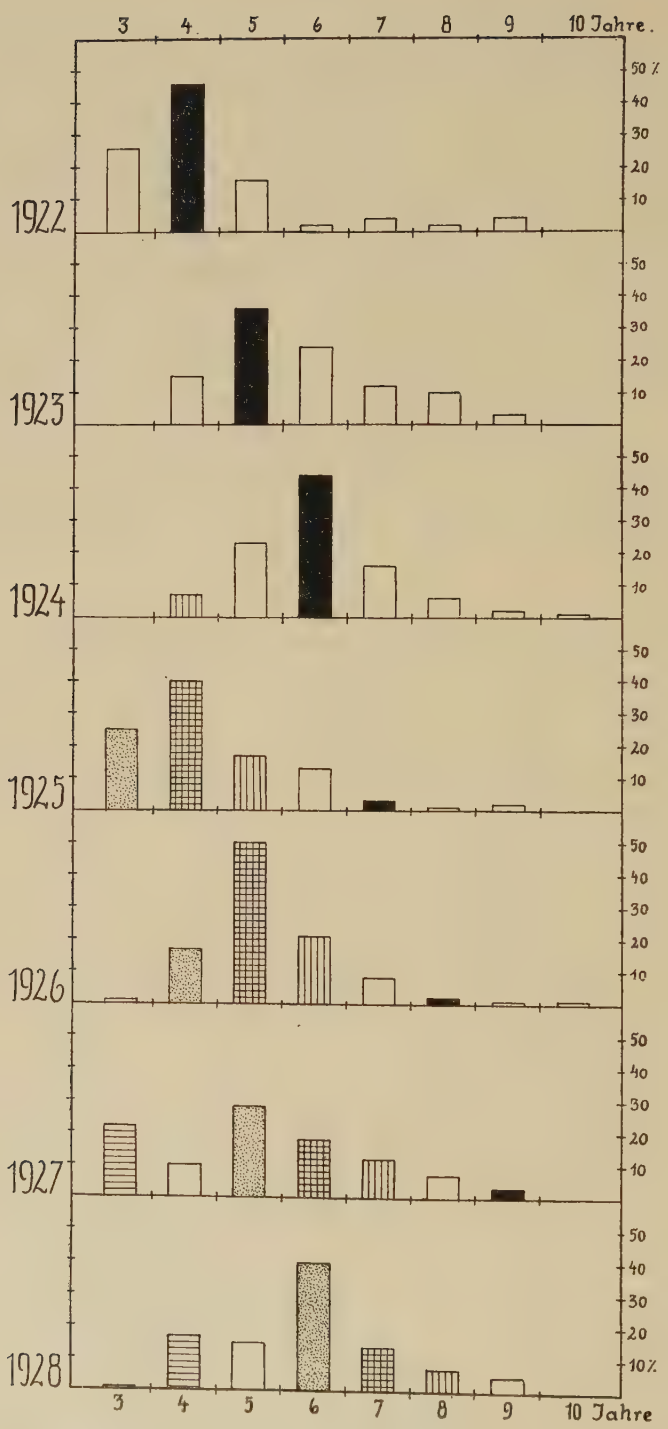


Fig. 1. Alterszusammensetzung der 1922—1928 auf dem Fladengrund gefangenen Heringsproben.

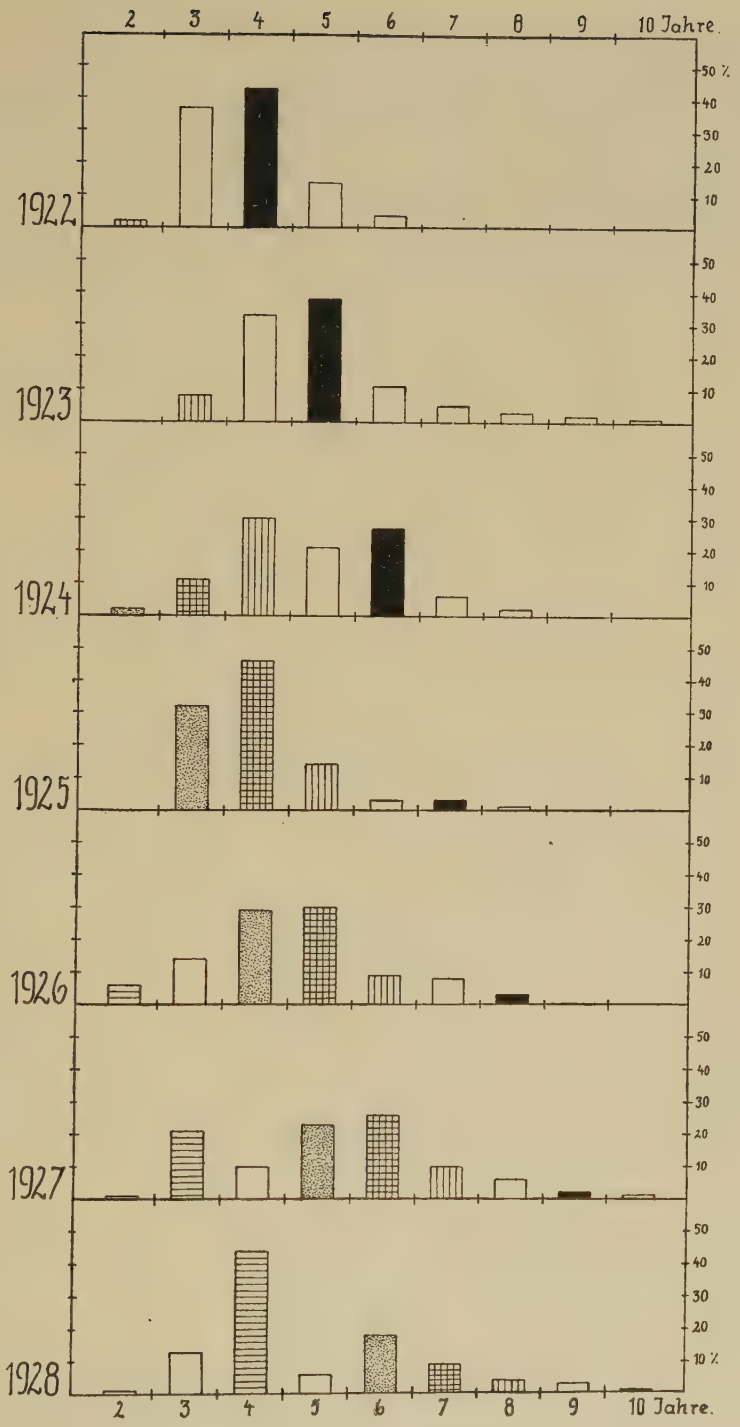


Fig. 2. Alterszusammensetzung der 1922—1928 auf der Doggerbank gefangenen Heringsproben.

foten als wirksam nachgewiesenen Ursachen auch auf die deutsche Trawlheringsfischerei in der Nordsee anwendet.

Hjort sprach schon 1914 die Ansicht aus, dass die Fluktuationen der Jahresklassen der bestimmende Faktor für die Schwankungen der Fischerei seien. Er sagt, dass in jedem Jahre wechselnde Mengen junger, erstlaichender Kabeljau in die Laichschwärme einwandern, und dass, wenn ein besonders reicher Jahrgang einwandert, er die Durchschnittslänge und das Durchschnittsgewicht der gefangenen Tiere stark herabsetzt und dadurch das Fangergebnis zunächst ungünstig beeinflusst. In den fol-

Fig. 3. Durchschnittserträge eines deutschen Heringtrawlers pro Reise in den Jahren 1920—1928 in 1000 Pfund.

genden Jahren werden sich dann mit dem Heranwachsen dieses Jahrganges auch die Erträge wieder heben.

Vergleicht man nun die beiden Tafeln über die Alterszusammensetzung der Heringe auf dem Fladengrund und der Doggerbank mit der Kurve der Erträge der Fischerei (Figur 3), so findet man eine Bestätigung der von Hjort für den Kabeljau ausgesprochenen Ansicht auch beim Bankhering. Die schlechten Fangjahre heben sich für beide Plätze sofort dadurch heraus, dass in ihnen der Gipfel der Alterskurve nach links verschoben ist, und bei 4 Jahren liegt. Sehr klar ist das der Fall in den Jahren 1922 und 1925, wo auf dem Fladen die 3- und 4-jährigen Heringe mit 72 und 65 %, auf der Doggerbank sogar mit 80 und 78 % vertreten sind.

Für 1924 und 1927, die keine ausgesprochen schlechten Fangjahre waren, die aber beide ein Nachlassen der Fischerei gegenüber den vorangegangenen Jahren aufweisen, liegen die Dinge etwas anders. 1924 verlief die Alterskurve der auf dem Fladengrunde gefangenen Heringe völlig normal, sodass danach ein guter Fang zu erwarten

war. Auf der Doggerbank dagegen traten in stärkerem Masse junge, 4-jährige Heringe auf, und es muss angenommen werden, dass sie die geringere Ergiebigkeit des Jahres verursachten. Allerdings deuten verschiedene Umstände darauf hin, dass ausserdem noch andere Einflüsse für den Ausfall der Fischerei von Bedeutung waren.

Im Jahre 1927 traten neben den alten Beständen zahlreiche 3-jährige Tiere auf, und es unterliegt keinem Zweifel, dass sie die Saisonergebnisse ungünstig beeinflussten.

Die Beziehungen zwischen der Zusammensetzung der Heringsschwärme und den Erträgen der Fischerei sind klar genug. Doch bilden die Fluktuationen der Jahresklassen — es sei an die Saison 1924 erinnert — nicht den einzigen bestimmenden Faktor für die Höhe der Ausbeuten.

Schon 1925 habe ich mehrfach darauf hingewiesen, dass, neben der starken Verjüngung der Bestände in dieser Saison, auch die Ernährung der Heringe, also ihr Wachstum und ihr Gewicht, mit in Betracht zu ziehen sind.

In der Tat war 1925 die geringe Durchschnittslänge der gefangenen Tiere nicht nur eine Folge der starken Verjüngung der Bestände, sie wurde auch durch mangelhafte Ernährung der Heringe in der vorangegangenen Wachstumsperiode hervorgerufen und das dadurch bedingte geringe Wachstum der für den Fang hauptsächlich in Betracht kommenden Jahresklassen.

In Grossbritannien und Norwegen ist es seit langem üblich, an den für die Altersbestimmung benutzten Schuppen nach der von E. Lea ausgearbeiteten Methode die Breite der Jahresringe zu messen und diese Masse zur Berechnung des Wachstums der Heringe zu verwenden. Solche Berechnungen, die es bis zu einem gewissen Grade gestatten, das Schicksal eines jeden Individuums zu rekonstruieren, sind von uns bisher nicht gemacht. Stets aber wurden an Hand der Altersbestimmungen die mittlere Länge jeder Altersgruppe in allen Untersuchungsperioden berechnet, sodass wir über die Wachstumsgeschichte der einzelnen Jahresklassen recht gut unterrichtet sind. Die so erhaltenen Werte haben zudem noch den Vorteil, auf direktem Wege durch Längenmessungen erhalten zu sein und können daher als genau angesehen werden. Sie liefern den Nachweis einer im Verhältnis zum Alter der Tiere zu geringen Länge der in einigen schlechten Fangjahren erbeuteten Heringe.

Zur Illustration des Gesagten sind nachfolgend die mittleren Längen der 3- bis 7-jährigen Tiere vom Rande der Doggerbank in den Jahren 1922 bis 1928 aufgeführt.

Im allgemeinen ist ein 3-jähriger Hering 22,3 cm lang, ein 4-jähriger 23,4 cm, ein 5-jähriger 24,3 cm, ein 6-jähriger rund 25 cm und ein 7-jähriger 26 cm. Im Jahre 1922 aber waren die 3- und 4-jährigen Tiere, welche den Hauptteil der Fänge ausmachten, nur 22,0 bezw. 22,4 cm lang. Im Jahre 1923, nun 4- und 5-jährig, waren sie wieder gut gewachsen, und ebenso 1924. 1925 aber hatten die 3-jährigen Tiere nur eine Länge von 21,6 cm und die 4-jährigen von 22,4 cm, waren somit, und ebenso auch die älteren Jahrgänge, unzureichend gewachsen. 1926 konnten sie alle kräftig nachwachsen, nicht aber die Angehörigen des Jahrganges 1920, die anscheinend besonders schwer geschädigt waren, da sie auch 1927 viel zu klein blieben. 1927 zeigten die für den Fang sehr wichtigen 3-jährigen Heringe eine bedeutende Unterlänge, während im Jahre 1928 alle Tiere hervorragend gut gewachsen waren, was auf ausgezeichnete Lebensbedingungen

| | 3 | 4 | 5 | 6 | 7 Jahre |
|---|---|---|---|---|---|
| 1922 | **22,0** | **22,4** | 24,1 | 26,2 | .. cm |
| 1923 | 22,3 | **23,3** | **24,1** | 26,5 | 26,5 cm |
| 1924 | **22,3** | 23,4 | 24,5 | **25,6** | 26,8 cm |
| 1925 | **21,6** | **22,4** | 23,8 | 25,0 | **24,5** cm |
| 1926 | 22,2 | **23,3** | **23,5** | 24,4 | 25,4 cm |
| 1927 | **21,3** | 23,3 | **24,3** | **24,1** | 24,5 cm |
| 1928 | 22,5 | **23,8** | 24,9 | **25,8** | **27,3** cm |
| Normal | 22,3 | 23,4 | 24,3 | 25,0 | 26,0 cm |

für die Heringe in der zwischen den beiden Fangzeiten liegenden Wachstumsperiode hindeutet.

Dem geringen Längenwachstum der Heringe in bestimmten Jahren entspricht auch ein geringeres Gewicht als das normale. So gingen im Jahre 1925 in der Nordsee 5 Heringe auf ein Pfund (= 500 g), in anderen Jahren aber nur 4. Schätzt man danach die gefangenen Heringsmengen, so kommt man zu dem Schlusse, dass 1925 der Stückzahl nach nicht weniger Heringe gefangen wurden als sonst, dass also wohl auch nicht weniger Heringe in der Nordsee vorhanden waren.

Über das bisher Aufgezeigte hinaus spielt aber die Ernährung eine Rolle beim Ausfall der Heringsfischerei. Die Qualität der Heringe wechselt nach Fettgehalt und Zustand des Fleisches von Jahr zu Jahr. So bezeichneten die deutschen Fischer die Qualität der Heringe in den Jahren 1923, 1926 und 1928 als sehr gut, 1922 und 1925 als sehr schlecht, 1924 und 1927 als mittel. Sieht man von den Jahren 1922 und 1925 ab, in denen die schlechte Ernährung das Wachstum der Tiere hemmte, so lässt sich für die Jahre 1924 und 1927, in denen die Heringe normale Längen erreichten, sehr wohl annehmen, dass das für das einzelne Tier nur geringfügig erniedrigte Körpergewicht einen Einfluss auf das Gesamtergebnis der Fischerei auszuüben im Stande war. Es gelang mir zwar, für diese Behauptung zahlenmässige Unterlagen zusammenzustellen, doch verzichte ich auf deren Wiedergabe, da sie nicht hinreichend klar erscheinen. Es sei aber darauf hingewiesen, dass der Rückgang der deutschen Trawlheringsfischerei im Jahre 1924 sich durch die Verjüngung der Bestände schwerlich erklären lässt, wohl aber, wenn man eine Beeinflussung des Körpergewichtes, nicht aber des Wachstums, durch die Ernährung in diesem Jahre annimmt.

Wir haben somit jetzt schon zwei Faktoren, welche die Ergiebigkeit der Heringsfischerei beeinflussen, einmal die Alterszusammensetzung der Bestände, dann die Ernährung der Tiere. Durch ihre Bestimmung gelingt es, seit 1925 in grossen Umrissen eine Voraussage über den Gang der Fischerei zu machen. Es geschieht dies so, dass nach Schluss einer Saison festgestellt wird, welche Jahrgänge während ihrer Dauer vornehmlich in den Schwärmen vertreten waren, wie lange sie schon einen Bestandteil

der Fänge bildeten, und welche Jahresklassen voraussichtlich in der kommenden Saison am stärksten vertreten sein würden, schliesslich, wie diese Tiere bisher gewachsen waren. Diese Voraussagen trafen hinsichtlich der Zusammensetzung der Schwärme in der neuen Saison stets zu, während die Frage nach dem Wachstum und der Qualität nur zu einem Teil beantwortet werden kann, da es nicht möglich ist, vorauszusagen, wie die Ernährungsverhältnisse für die Heringe sich zwischen den beiden Fangzeiten gestalten wird.

Zudem spielt noch ein dritter Faktor eine nicht zu unterschätzende Rolle in der Bankheringsfischerei. Aus allen meinen Ausführungen geht immer wieder hervor, dass auf dem nördlichen Fangplatze, dem Fladengrunde, die Heringe älter, daher auch grösser sind als auf dem südlichen, der Doggerbank. Es ist somit nicht gleichgültig, wie lange die Fischerei im Norden ausgeübt werden kann. 1926 z. B. waren rund 40 % der von Deutschland ausgeführten Heringsfangreisen nach dem Fladengrunde gerichtet, 1927 dagegen nur 34 % und 1928 44 %. Unzweifelhaft ist der namentlich finanziell unbefriedigende Ausfall der Fischerei 1927 auf die kurze Dauer der Fladengrundfischerei zurückzuführen, da dieser Platz nur im August befischt werden konnte, 1928 aber von Ende Juli bis Mitte Oktober.

Schliesslich sei nicht vergessen, dass in manchen Jahren ungünstige Witterungsverhältnisse die Ausübung der Fischerei sehr behindern können.

Aus den vorliegenden Ausführungen dürfte sich ergeben, dass es das Zusammenwirken einer ganzen Reihe von Einflüssen ist, welches die Fluktuationen in der Heringsfischerei hervorruft. Zur Erklärung der ersten beiden Faktoren, der Veränderungen in der Zusammensetzung der Heringsschwärme, wie der wechselnden Ernährungsbedingungen für die Heringe in den verschiedenen Jahren hat man hydrographische Momente herangezogen, und besonders an den mehr oder minder starken Einstrom atlantischen Wassers in die Nordsee gedacht. Es ist sicher, dass Einflüsse dieser Art geeignet sind, nicht nur die eben genannten Faktoren, sondern auch die wechselnde Dauer der Fischerei auf dem Fladengrund zu erklären. Wie man sich aber im Einzelnen den Einfluss der wechselnden hydrographischen Situation in der Nordsee auf die Heringsbestände zu denken hat, das ist leider noch völlig ungeklärt.

## Résumé.

The remarkable results of the Norwegian studies of the fluctuations in the yield of the Cod and Herring fisheries have provoked similar investigations in the German Trawl Herring Fishery. The composition of the stock in view of different year classes has been examined at every possible occasion since 1922. Therefore we possess a rather comprehensive material to form an opinion of our own in this matter and we are able to state whether the renewal of the stock only or other influences in connection with it are responsible for the fluctuations in the North Sea Herring Fishery.

The herring concerned here is the filling Bank herring of the Western North Sea and the principal fishing grounds are the Fladden Ground in the North and the Dogger Bank in the South.

On the Fladden Ground from 1922 to 1924 the prevailing year class was that of 1918. In 1922 these four years old fish were too young and therefore had a bad in-

fluence on the yield of the fishery. But when the 1918 fish grew older and longer the fishery became better in the following years.

In 1925, however, which was the worst herring year after the war, the 1918 year class had disappeared whilst the strongest year class now was that of 1921 and, in a lesser degree, that of 1922. How complete the renewal of the stock by this change has been is obvious from the fact that in 1924 the mean age of the herring caught was 6 years against 4.2 years in 1925.

In 1926 and 1927 the growing year classes of 1921 and 1922 had a good influence on the fishery, but in 1927 the appearance of the new year class of 1924 caused a slight decrease in the average age of the fish. In 1928 all year classes showed an excellent growth and the fishery was a good one.

On the Dogger Bank we find the same situation with slight differences. For in 1924 the main year class was that of 1920 and in 1928 that of 1924. On the Fladden there are never caught herrings less than 3 years old, i. e. only mature fish, whereas on the Dogger occur unripe fish which are 2 years old. Therefore, every new year class appears one year earlier on the Dogger Bank and the herrings caught there are, on an average, younger than those from the Fladden.

As stated by Hjort for the cod, we find that every year with an unusual strong renewal of the herring shoals in the North Sea shows a decrease in the yield of the Trawl Herring Fishery.

But there are other causes, too, responsible for the fluctuations of this fishery. Firstly the nourishment of the herrings. In 1925 I was able to show that not only the age of the herrings had decreased but also length and weight. Normally a three years old herring has a length of 22.3 cms., one of four years of 23.4 cms., and one of five years 24.3 cms. In 1925 these lengths only were 21.6 cms., 22.4 cms. and 23.8 cms. Especially the year class 1920 suffered very much by this famine as its average length in 1926 and 1927 was far from being normal. The same could be shown by the weight of the herrings as the mean weight of a single herring is 125 g. and in 1925 reached only about 100 g.

As there is a marked difference in the age of the herrings from the Fladden and from the Dogger Bank and therefore in their length too, every fishing year will be influenced by the duration of the fishery on the northern ground. In 1927 our fishermen found herrings in the North during August only, but in 1928 from the end of July to the middle of October. Therefore 1927 was a bad year, especially financially, 1928 a very fine one.

At last it should be mentioned that bad weather, too, influences the fishery in the open sea.

A good year class of the Bank herring has its influence on the stock for three years and may be present in the shoals for eight years whilst a similar year class of Norwegian herrings influences the stock for eight years and is present in the shoals for ten to fifteen years.

The quick change in the renewal of the stock of the Bank herring simplifies a prediction for the following year and involves an advantage as compared with the possibilities in the Norwegian herring.

# XVII. Year classes of Herring in the Southern North Sea in the Winters of 1927—1928 and 1928—1929.

By

**J. J. Tesch.**

In the winters of 1927—1928 and 1928—1929 we examined on various occasions samples of herring scales, in the course of investigations regarding the races of herring of the Southern North Sea. Three different workers examined the scales independently and we afterwards compared our results and tried to come to a conclusion in case of disagreement. Nevertheless I should not have ventured to publish these findings, were it not for the fact that they tallied so well with HODGSON's, a résumé of which was received shortly before our London meeting, that I thought it better not to keep away ours.

Our material consisted in each winter of four samples out of catches by the ordinary driftnet fishery and consisting mostly of about 200 individuals. They were landed at Ymuiden and we don't know the exact size of the meshes of the nets in which the herrings were caught. We may assume the number of meshes to be 35—38 per yard, this being the usual size of the Scottish nets most commonly used, but the uncertainty about it is a serious drawback to calculations. As HODGSON in Journ. du Cons. Vol. II, No. 3, 1927 pointed out, the number of older (or rather: larger) fish varies according to the size of the meshes, and the actual composition of the stock of fish is not to be found except by using a number of different meshes. As a matter of fact, however, we have to rely upon the age investigations in samples like these lying before us. The following table shows the percentage of frequency of the various year classes.

A. November, 1927—January, 1928.

| Year... | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|
| Sandettie L.V. Nov. 23rd 1927, 98 ind..... | — | 12.2 | 37.8 | 39.8 | 7.1 | 3.1 | — | — | — |
| Smith Knoll L.V. Nov. 30th 1927, 195 ind..... | 13.3 | 13.9 | 25.6 | 28.2 | 12.8 | 5.1 | 0.5 | — | 0.5 |
| 78′ N.W. of Ymuiden Dec. 9th 1927, 200 ind. ... | 1.5 | 11.0 | 32.0 | 38.0 | 11.5 | 5.5 | 0.5 | — | — |
| 15′ N.W. of Dieppe Jan. 13th 1928, 200 ind..... | 2.5 | 11.0 | 36.5 | 39.5 | 10.0 | 1.0 | — | — | — |
| Total... | 4.9 | 12.0 | 32.3 | 35.8 | 10.8 | 3.7 | 0.4 | — | 0.1 |

## B. November—December, 1928.

| Year... | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|
| 72′ N.W. of Ymuiden Oct. 17th 1928 200 ind..... | 12.0 | 74.5 | 12.5 | 1.0 | — | — | — | — |
| Smith Knoll L.V. Oct. 31st 1928, 197 ind..... | 2.0 | 43.7 | 22.8 | 17.8 | 11.7 | 2.0 | — | — |
| Smith Knoll L.V. Nov. 19th 1928, 188 ind..... | 9.0 | 37.8 | 34.1 | 12.2 | 6.9 | — | — | — |
| 30′ S.E. of Yarmouth Dec. 4th 1928, 175 ind. ... | 3.4 | 6.9 | 12.0 | 30.3 | 27.4 | 13.7 | 4.0 | 2.3 |
| Total... | 6.7 | 41.8 | 20.4 | 15.0 | 11.1 | 3.7 | 1.0 | 0.3 |

The following figures give a graphic representation of the percentages in the samples of 1927—28 (fig. 1—4), of 1928—29 (fig. 5—8), while fig. 9—10 give these percentages in all samples taken in these two winters.

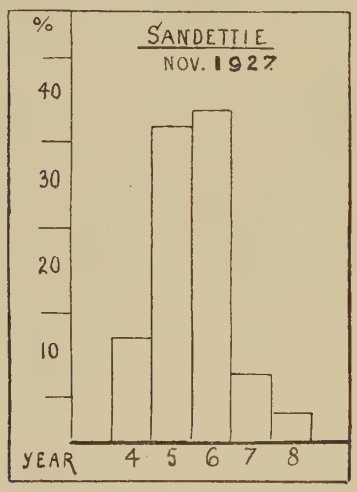


Fig. 1.

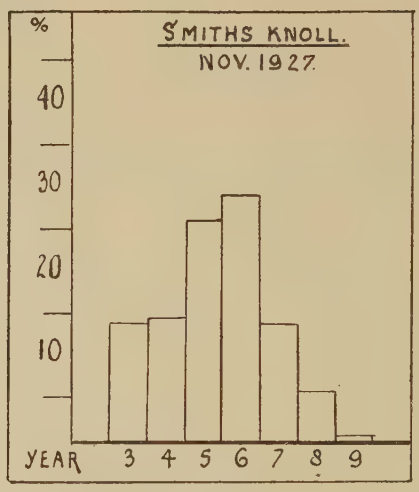


Fig. 2.

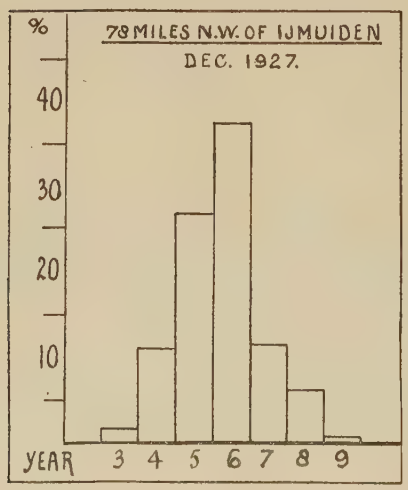


Fig. 3.

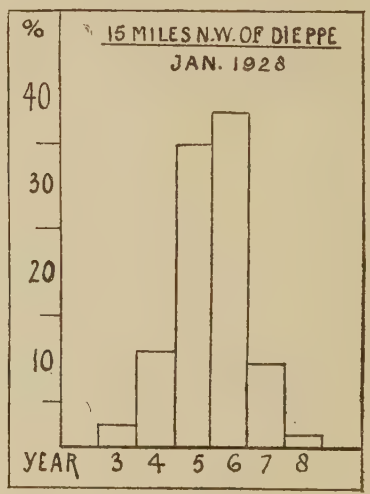


Fig. 4.

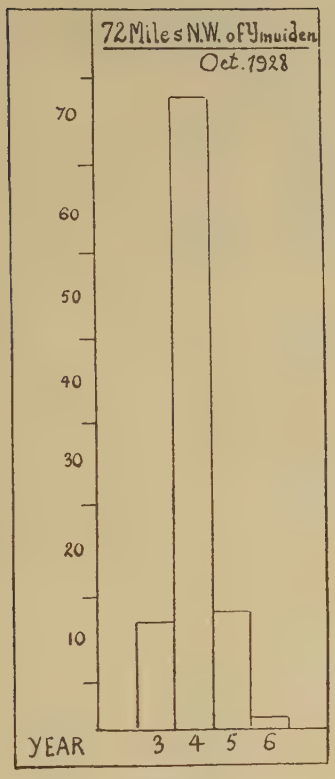


Fig. 5.

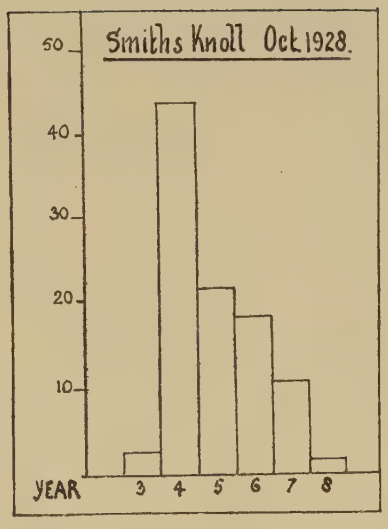


Fig. 6.

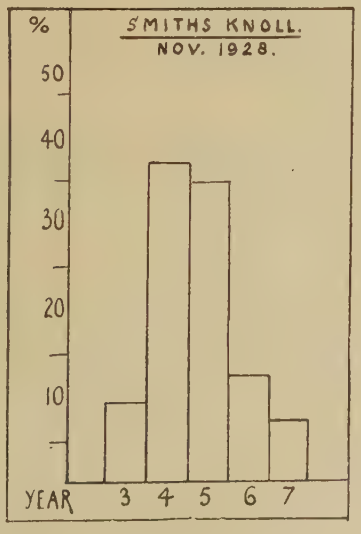


Fig. 7.

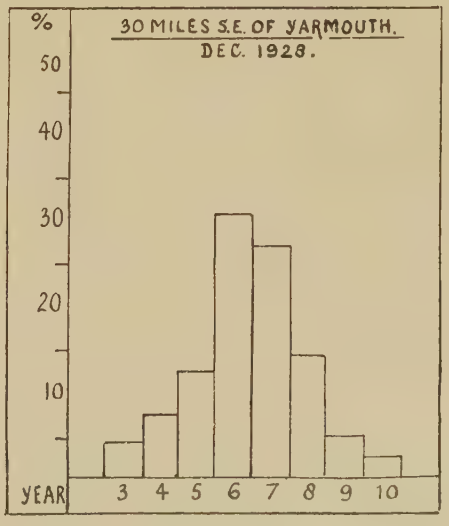


Fig. 8.

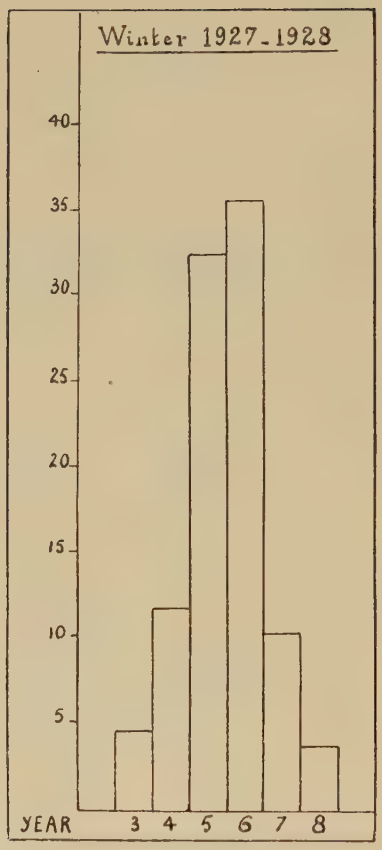


Fig. 9.

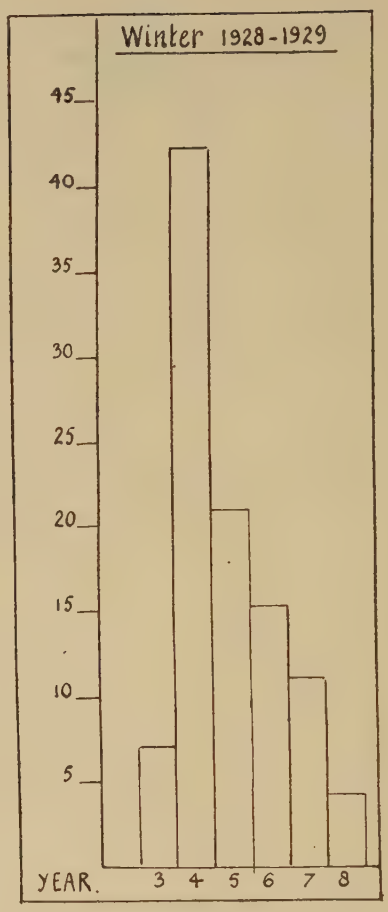


Fig. 10.

We conclude from the foregoing:—

1° In the winter of 1927—28 the year classes 5 and 6 (viz. of birth years 1922 and 1921) formed the bulk of the catch; in all samples the 1921 herrings were slightly more numerous than those of the 1922 year class. These year classes in all samples together make up 68 per cent. of the catch.

2° In the winter of 1928—29 the before mentioned year classes have largely diminished, though still yielding 15 per cent. and 11 per cent. respectively. But the 1924 year class now appears as "recruits" in the first sample of this winter to such an extent as to outnumber all other groups; later on this class decreases in number, till in the last sample it is crowded out by the 6th and 7th year classes: the very year groups 1922 and 1921 that played such an important part in the foregoing winter. Nevertheless the 1924 herring alone constitute about 42 per cent. of the catch, while another 26 per cent. is made up of the year classes 1922 and 1921, now 6 to 7 years old, respectively.

As Hodgson pointed out, the 1921 year class resulted from a winter spawning,

the 1922 class from an autumn spawning; that of 1924 consists of an accumulation of spawnings, extending from the summer of 1924 till well into the winter of 1925 and this may explain this group being so numerous. The brood of 1923 constituted in 1927 only 12 per cent. of the catch, in the following season it reached 20 per cent.

Owing to the uncertainty about the meshes of the gear with which our samples were taken we had better abstain from calculations of $l_1$ and successive lengths of year classes. As has been said, it was only the fair agreement with HODGSON's results concerning the same area and the same seasons which made us publish our findings.

# XVIII. Statistiques biologiques et considérations sur la population harenguière de la Manche Orientale.

Par

**Jean le Gall,**

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Ces quelques observations sur la population harenguière de l'entrée Orientale de la Manche ont le grave défaut de n'avoir porté que sur un nombre relativement restreint d'années: de 1926 à 1928, c'est à dire pendant les trois dernières saisons de pêche du hareng dans cette région.

Elles ne peuvent donc avoir aucun caractère définitif.

Mais, la méthode qui a présidé aux prélèvements des échantillons étudiés au cours de ces trois années étant sensiblement différente de celle couramment employée dans les recherches de ce genre, nous avons tenu à exposer, dès maintenant, les résultats obtenus, non point pour la valeur intrinsèque des résultats eux mêmes, mais surtout pour soumettre à l'appréciation de la critique la valeur de la méthode employée.

Il est encore fréquent de constater que le Biologiste qui se propose de rechercher les lois de la répartition d'une population ichthyologique, quant à l'âge, la taille, le poids, le sexe ou la maturité, s'est contenté de faire un seul prélèvement plus ou moins important, ou quelques rares prélèvements indifféremment répartis comme lieu et date, au cours de la saison d'apparition et de rassemblement de ce poisson.

Il croit pouvoir en tirer des conclusions exactes. Or, cette méthode est éminemment fausse, car, en ne prenant comme exemple que le hareng, si nous n'avons, à priori, aucune idée sur le nombre d'individus pouvant constituer un des rassemblements de ponte de cette espèce dans une région quelconque, nous n'avons également qu'une idée assez imprécise sur la durée et l'époque exacte de ces rassemblements. De plus, rien n'indique que la répartition de ces individus, aux différents points de vue envisagés; taille, âge, poids, sexe, maturité, reste constamment la même pendant toute la durée de ces rassemblements. Il est au contraire très probable qu'elle est très variable dans la même région suivant le moment et le lieu.

Pour se faire une idée, tant soit peu exacte, de la répartition de cette population, des prélèvements quelconques, indifféremment effectués ne peuvent donc suffire, et il est absolument nécessaire de suivre constamment les rassemblements de cette po-

pulation, et d'y faire, en divers points, à des intervalles réguliers et aussi rapprochés que possible, le plus grand nombre possible de prélèvements.

C'est ce que nous avons fait dans nos recherches sur le hareng et en particulier pour le hareng de l'entrée de la Manche Orientale.

Pendant toute la durée de la saison de pêche (époques des rassemblements) dans cette région, les positions des bateaux de pêche ont été régulièrement relevées et des prélèvements régulièrement effectués (trois en moyenne par semaine) soit: à bord des bateaux de pêche, sur la pêcherie même, quand les occasions nous y ont amené, soit: à l'arrivée des bateaux, au moment du débarquement sur les quais de Boulogne.

De plus, ces prélèvements n'ont pas été faits sur un bateau quelconque, mais, sur plusieurs bateaux provenant de la même pêcherie et ayant travaillé dans une zone déterminée, ceci de façon à constituer un seul lot qui a été examiné intègralement.

Nous pensons ainsi avoir obtenu, avec des prélèvements fréquents de lots d'une cinquantaine d'individus environ, régulièrement répartis au cours de toute la saison de pêche dans la région considérée, des résultats autrement probants qu'en ayant prélevé un, deux ou trois lots, fussent ils de 200, 500 ou 1,000 individus, indifféremment répartis comme lieu et date au cours de la même saison.

## Les rassemblements du Hareng en Manche Orientale et les déplacements de la pêcherie.

Il est de toute évidence que les rassemblements de harengs en Manche Orientale, de Gris Nez à l'embouchure de la Seine sont des rassemblements de ponte. Ce fait est vérifié:

1) Par l'examen des poissons pêchés dans toute cette région, et qui sont en grande majorité au Stade VI, avec un certain nombre au Stade V, et une égale proportion au Stade VII. En d'autres termes, tous les harengs pêchés pendant cette période, en Manche Orientale sont ou "francs", principalement "bouvards", ou "guais".
2) Par la constatation sur les bateaux de pêche, et en de nombreux points de la pêcherie, de harengs "bouvards" (Stade VI) et dont le sperme ou les œufs s'écoulent sur le pont au moment de la capture.
3) Par la constation sur ces mêmes fonds de nombreux œufs de harengs (appelés "roguis" par les pêcheurs et ramenés dans les bas de filets quand ceux ci traînent sur les hautures, ou par les chalutiers opèrant dans le voisinage.
4) Enfin par l'examen du contenu stomacal des différents poissons pêchés dans la même région et qui, à certains moments, est presque uniquement constitué par des oeufs de harengs.

Ces rassemblements ont lieu de fin d'Octobre à la fin de Janvier dans une région qui pourrait se délimiter en menant une ligne droite hypothétique, passant à une dizaine de milles au large d'Antifer et allant rejoindre le South Foreland, sur la côte anglaise, en passant, ainsi, à une quinzaine de milles au large de Gris Nez. C'est à l'intérieur de cette ligne: c'est à dire vers l'Est, et dans la zone comprise entre Gris Nez et Antifer que ce font principalement ces rassemblements de harengs (Fig. 1).

Fig. 1. Zones de pêche du Hareng en Manche Orientale et limite des différents groupes étudiés. Les flèches indiquent la direction probable des déplacements des deux types constituant la population harenguière de cette région.

Nous tenons toutefois à faire remarquer, dès maintenant, que ce n'est pas exclusivement dans cette zone que se font les rassemblements de ponte en Manche Orientale; et, pour ne citer que deux exemples, nous pourrions signaler les fortes pêches parfois réalisées, de Novembre à Janvier, par les drifters anglais, à quelques milles au large de la côte anglaise: entre Beachy Head et le South Foreland, et celles réalisées également aux mêmes époques, autour de la presqu'ile du Cotentin entre le Cap de la Hague et la Hougue, par les pêcheurs de cette région.

Mais, la majorité des drifters de toutes nationalités qui, de Novembre à la fin de Janvier, opèrent en Manche Orientale tend toujours ses filets dans la région délimitée. Etant donné le nombre de ces drifters, leur grande pratique du métier qu'ils font, les

moyens rapides (T. S. F.) dont la plupart disposent pour être aussitôt renseignés sur les fluctuations et les déplacements possibles de la pêcherie (autrement dit des bancs de harengs), il y a tout lieu de croire qu'ils se trouvent, ou se trouveront, rapidement là où se trouve le poisson en quantité. C'est donc dans cette région qu'ont été faits nos prélèvements et c'est aux harengs de cette région que nous prétendons limiter l'étude présente.

Dans cette vaste région de plus de 1,500 milles carrés de superficie la pêcherie se déplace, assez régulièrement d'ailleurs, du Nord au Sud et du Sud au Nord (ce qui laisserait à penser que les déplacements des bancs de harengs sont liés aux conditions hydrologiques dans la région). Ainsi, au cours de la dernière saison de 1928 le gros de la pêcherie s'est successivement porté:

du 26 Octobre au 8 Novembre: de Gris Nez à l'embouchure de la Somme.
du 8 Novembre au 20 Novembre: de l'embouchure de la Somme à Ailly.
du 20 Novembre au 30 Novembre: de Griz Nez à l'embouchure de la Somme.
du 1er au 20 Décembre: de l'embouchure de la Somme à Ailly.
du 18 Décembre au 1er Janvier: de l'embouchure de la Somme à Gris Nez.
du 1er au 25 Janvier: de l'embouchure de la Somme à Antifer.

Nous avons pu ainsi répartir les 1,100 harengs régulièrement prélevés dans la région Orientale de la Manche, de Gris Nez à Antifer, en deux grands groupes:

**Groupe I.** Harengs provenant de la zone comprise de Gris Nez à la Somme.
**Groupe II.** Harengs provenant de la zone comprise entre la Somme et Antifer.

Dans chacun de ces groupes nous avons fait des subdivisions suivant les époques de pêches. C'est ainsi que les harengs prélevés entre la Somme et Antifer ont été groupés en trois lots:[1])

**Lot I.** Harengs prélevés du 8 au 20 Novembre 1928.
**Lot II.** Harengs prélevés du 1er au 20 Décembre 1928.
**Lot III.** Harengs prélevés du 1er au 25 Janvier 1929.

Les harengs prélevés entre Gris Nez et l'embouchure de la Somme ont été également groupés en trois lots:

**Lot I.** Harengs prélevés du 26 Octobre au 20 Novembre 1928.
**Lot II.** Harengs prélevés du 21 au 7 Décembre 1928.
**Lot III.** Harengs pêchés du 18 Décembre 1928 au 7 Janvier 1929.

Nous avons fait pour cette région un quatrième lot avec des harengs, en grande majorité au Stade VII, c'est à dire "guais" ou ayant pondu, et, capturés soit par les

[1]) Tous les bateaux ne se portent pas à la fois sur la même pêcherie. Nos prélèvements dans chaque zone se sont poursuivis tant qu'il y a eu quelques bateaux dans cette zone, c'est à dire avant l'arrivée et après le départ du gros de la pêcherie. Ceci explique pourquoi nos dates de prélèvements dans chaque lot peuvent ne pas coïncider avec les grands déplacements de la pêcherie.

chalutiers, soit aux filets dérivants, du 7 au 25 Janvier 1929. Enfin, un groupe spécial groupe III, a été constitué avec un certain nombre de harengs prélevés en Décembre et Janvier, dans le voisinage des côtes anglaises: du Varne au Royal Sovereign, et ceci à titre de comparaison avec les harengs prélevés sur la côte Est de l'entrée Orientale de la Manche.

Dans chacun de ces lots, les échantillons prélevés ont été étudiés suivant la technique habituelle, les observations ayant porté sur:

la taille en centimètres, ramenée au nombre entier le plus voisin.
le sexe et la maturité établie d'après les stades préconisés par J. Hjort.
l'âge et la croissance calculés après lecture de l'écaille.
le nombre de vertèbres.

Dans l'examen des résultats nous ne tiendront provisoirement compte que de la taille, de l'âge et du nombre de vertèbres: la maturité, étant d'une façon presque générale au Stade VI ayant été volontairement laissée de coté, et l'étude de la croissance devant faire l'objet d'un travail ultérieur.

## Harengs de l'entrée Orientale de la Manche.

### Groupe I.

De Gris Nez à l'embouchure de la Somme.

Premier Lot. Echantillons prélevés du 26 Octobre au 20 Novembre. 245 Harengs étudiés.

Deuxième Lot. Echantillons prélevés du 21 Novembre au 7 Décembre. 142 Harengs étudiés.

Troisième Lot. Echantillons prélevés du 7 Décembre au 7 Janvier 1929. 86 Harengs étudiés.

Quatrième Lot. Echantillons prélevés du 7 Janvier au 25 Janvier 1929 (constitué en majorité par des harengs "guais" (Stade VII)). 110 Harengs étudiés.

Taille.

Dans chacun de ces lots, la répartition des individus par taille peut s'établir ainsi:[1])

| Centimètres | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | Taille moyenne |
|---|---|---|---|---|---|---|---|---|---|
| Lot I ..... % | 2,8 | 22,8 | **33,5** | 22,1 | 17,6 | 1,2 | .. | .. | 24,85 |
| Lot II ..... % | 1,4 | 7,1 | 19,7 | 24,6 | **27,5** | 16,9 | 2,8 | .. | 25,82 |
| Lot III ..... % | .. | 1,2 | 16,3 | 29,1 | **40,7** | 11,6 | 1,2 | .. | 25,98 |
| Lot IV ..... % | 1,8 | 4,6 | 15,5 | 32,7 | **34,6** | 7,3 | 3,6 | 0,9 | 25,84 |
| Moyenne des quatre lots... % | 1,5 | 8,9 | 21,2 | 27,1 | **30,1** | 9,2 | 1,9 | 0,2 | 25,62 |

[1]) Dans chaque lot le mode est indiqué en caractères gras.

Il est à remarquer que la taille moyenne du lot I est nettement inférieure (1 centimètre) à la taille moyenne des lots II, III, IV, apparus ultèrieurement sur les fonds de pêche. Dans ce lot I, ce sont les harengs de petite taille, au dessous de 25 centimètres qui dominent, dans les lots suivants ce sont, au contraire, les harengs au dessus de 25 centimètres qui l'emportent.

Age.

La répartition par âge donne les résultats suivants:

| Anneaux d'hiver ..... | 2 | 3 | 4 | 5 | 6 | 7 | 8 | plus de 8 |
|---|---|---|---|---|---|---|---|---|
| Lot .....% | 2,1 | **71,8** | 6,9 | **11,1** | 6,1 | 2,0 | .. | .. |
| Lot II.....% | 3,5 | **33,1** | 12,7 | **28,9** | 15,5 | 6,3 | .. | .. |
| Lot III.....% | 4,6 | **20,9** | 18,6 | **27,9** | 19,8 | 5,8 | 1,2 | 1,2 |
| Lot IV .....% | 0,9 | **25,5** | 12,7 | **30,9** | 19,1 | 8,2 | 2,7 | .. |
| Moyenne des quatre lots...% | 2,7 | **37,8** | 12,7 | **24,7** | 15,1 | 5,5 | 0,9 | 0,3 |

Quelques soient les lots envisagés on peut remarquer:

1° que deux classes dominent dans chacun:

Les harengs à trois anneaux d'hiver, c'est à dire ayant quatre ans ou nés au cours de la saison harenguière en Manche Orientale, d'Octobre 1924 à Février 1925, et les harengs à cinq anneaux d'hiver, c'est à dire ayant six ans, ou nés au cours de la saison harenguière en Manche Orientale, d'Octobre 1922 à Février 1923.

2° la faible proportion de harengs de cinq ans c'est à dire à quatre anneaux d'hiver, nés en 1923, dans chacun de ces lots.

En comparant le pourcentage des âges dans chacun des lots, on peut encore constater:

— que les harengs de trois ans (2 anneaux d'hiver) ont été relativement de plus en plus nombreux sur les frayères sises entre l'embouchure de la Somme et le Cap Gris Nez, à mesure que s'avançait la saison: d'Octobre à Décembre, et qu'ils avaient sensiblement diminué au cours de Janvier.

— que les harengs de quatre ans (3 anneaux d'hiver) qui dominaient nettement au début de la saison de pêche, Octobre—Novembre diminuèrent ensuite de plus en plus jusqu'à la fin de la saison, avec toutefois une légère recrudescence dans le courant de Janvier (Lot IV). — On se rappellera cependant que ce lot était constitué par des harengs en majorité "guais", c'est à dire ayant pondu depuis quelque temps.

— que les harengs de plus de quatre ans (4 anneaux d'hiver et plus) sont au contraire de plus en plus nombreux à mesure que s'avance la saison. Autrement dit: En Manche Orientale, dans la zone de Gris Nez à l'embouchure de la Somme, la ponte de chaque classe, (exeption faite pour les jeunes harengs de 3 ans), est d'autant plus tardive que les harengs sont plus âgés, et, comme les bancs successifs qui se concentrent dans cette région sont uniquement des bancs de ponte, il est encore permis de dire: que d'Octobre à Janvier, les bancs qui se succèdent dans cette région sont proportionellement con-

stitués par des individus de plus en plus âgés. C'est ce que montre d'ailleurs l'âge moyen de chaque lot:

| | |
|---|---|
| Lot I | 4 ans 55 |
| Lot II | 5 ans 38 |
| Lot III | 5 ans 65 |
| Lot IV | 5 ans 77 |

et explique la taille croissante également rencontrée dans ces lots successifs.

Ces constatations viennent encore vérifier celles faites au cours de la saison 1927 dans la même région[1]).

### Vertèbres.

L'examen du nombre des vertèbres d'un certain nombre de harengs prélevés dans chaque lot, ne nous a pas montré la nécessité de maintenir, pour ce caractère, la répartition en quatre lots que nous avions adoptée pour l'âge et la taille. Un seul groupe, correspondant aux échantillons prélevés de Gris Nez à l'embouchure de la Somme, a été constitué avec 232 harengs et a donné les résultats suivants:

| Vertèbres | Fréquence |
|---|---|
| 54 | 3 |
| 55 | 8 |
| 56 | 103 |
| 57 | 106 |
| 58 | 12 |
| | $n$ = 232 |
| | Mode = 57 |
| | Moyenne = 56,50 |
| | Indice de variabilité: $\sigma = \pm$ 0,7 |
| | Fluctuation probable de la moyenne: $Fl = \pm$ 0,15 |

En résumé, les bancs successifs de harengs qui se sont rassemblés pour la ponte, à l'entrée de la Manche Orientale, de Gris Nez à l'embouchure de la Somme, peuvent être caractérisés ainsi: (Saison 1928).

Taille moyenne calculée sur le lot total:

25 centimètres 62.

| | |
|---|---|
| Classes dominantes: 26 | 30 % |
| 25 | 27 % |
| 24 | 21 % |

Au début de la saison, Octobre—Novembre, les harengs de petite taille: (au dessous de 25 centimètres) dominèrent, plus tard la taille s'élève sensiblement.

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[1]) J. Le Gall. Remarques et Statistiques biologiques sur les Harengs de la Mer du Nord, de la Manche et de l'Atlantique. Matériel de 1927. Revue des Travaux de l'Office Scientifique des Pêches Maritimes T. I. Vol. I.

Age: deux classes dominent nettement:

les harengs de quatre ans (3 anneaux d'hiver) 37,8 %
et les harengs de six ans (5 anneaux d'hiver) 24,7 %.

La forte proportion de harengs de quatre ans a son origine dans la forte proportion de harengs de trois ans signalés, déjà, au cours de l'année précédente. La pénurie de harengs de cinq ans (4 anneaux d'hiver) provient de la faible proportion de harengs de quatre ans également constatée et signalée l'an dernier.

Cette année se caractérise, en outre, par une très faible proportion de jeunes harengs de trois ans (2 anneaux d'hiver) dans les bancs de ponte. Ceci laisse à prévoir que les harengs de quatre ans (3 anneaux d'hiver) seront mal représentés dans les bancs de ponte au cours de la prochaine saison de 1929. Comme il a été montré que ce sont ces harengs qui constituent la grosse majorité des bancs de ponte, au début de la saison et dans la région considérée, il y a tout lieu de croire que le début de la saison harenguière en Manche, en 1929, sera inférieur comme rendement au début de la saison de 1928, ou sera légèrement en retard jusqu'à l'arrivée sur ces fonds des harengs de cinq ans (4 anneaux d'hiver) qui seront, cette année, bien représentés dans les bancs.

La taille moyenne des harengs donne pour la région en 1928:

| | | | | | |
|---|---|---|---|---|---|
| Moyenne observée: | 3 ans (2 anneaux)..... | 22 cms 82 | 6 ans (5 anneaux)..... | 25 cms 72 |
| | 4 ans (3 anneaux)..... | 24 cms 10 | 7 ans (6 anneaux)..... | 26 cms 01 |
| | 5 ans (4 anneaux)..... | 25 cms 29 | 8 ans (7 anneaux)..... | 26 cms 28 |

**Moyenne vertébrale: 56,50 avec $\sigma = \pm 0{,}7$ et $Fl = \pm 0{,}15$.**

**Groupe II.**

De l'embouchure de la Somme au Cap d'Antifer.

Premier lot. Du 8 au 20 Novembre 1928.
36 Harengs étudiés.
Deuxième lot. Du 1er au 22 Décembre 1928.
79 Harengs étudiés.
Troisième lot. Du 1er au 25 Janvier 1929.
256 Harengs étudiés.

Ici comme dans le groupe I il y a une succession de bancs de ponte dans toute la région, mais dans l'ensemble, la ponte est plus tardive dans cette région, car le maximum de concentration (et par conséquent de pêche) se produit surtout après la mi-Décembre, tandis que dans la première zone envisagée (Groupe I) il est antérieur à cette date.

Taille.

La répartition des individus, par taille, dans chacun de ces lots, s'établit ainsi:

| Centimètres | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | Taille moyenne |
|---|---|---|---|---|---|---|---|---|---|
| Lot I ..... % | .. | 11,1 | **38,9** | 27,8 | 16,6 | 5,5 | .. | .. | 25,16 |
| Lot II ..... % | .. | 5,1 | 20,2 | **29,1** | **29,1** | 10,1 | 6,3 | .. | 25,88 |
| Lot III ..... % | 0,4 | 3,5 | 17,6 | **32,8** | **32,8** | 10,5 | 2,3 | .. | 25,85 |
| Moyenne des trois lots... % | 0,13 | 6,6 | 25,6 | **29,9** | 26,2 | 8,7 | 2,8 | .. | 25,63 |

Ici encore, comme dans le groupe I, la taille moyenne du Lot I est sensiblement inférieure à la taille moyenne des lots suivants apparus ultérieurement sur les fonds de pêche. De même, dans ce lot, les harengs de petite taille, au dessous de 25 centimètres prédominent tandis que dans les deux lots suivants ce sont, au contraire, les harengs au dessus de 25 centimètres qui ont la prépondérance.

Il est à remarquer, enfin, que la taille moyenne de ces trois lots du groupe II. est très sensiblement la même que la taille moyenne des quatre lots du groupe I: 25,63 pour le groupe II et 25,62 pour le groupe I.

Age.

Les harengs du Groupe II se répartissent ainsi d'après l'âge:

| Anneaux d'hiver | 2 | 3 | 4 | 5 | 6 | 7 | 8 | plus de 8 |
|---|---|---|---|---|---|---|---|---|
| Lot I ..... % | 5,5 | **41,7** | 8,3 | **33,3** | 11,1 | .. | .. | .. |
| Lot II ..... % | 6,3 | **24,1** | 21,5 | **27,9** | 13,9 | 2,5 | 3,8 | .. |
| Lot III ..... % | 1,6 | **21,9** | 19,1 | **32,4** | 23,0 | 1,2 | 0,8 | .. |
| Moyenne des trois lots... % | 4,5 | **29,2** | 16,3 | **31,2** | 16,0 | 1,2 | 1,5 | .. |

Les mêmes classes, à savoir: les harengs de quatre ans (trois anneaux d'hiver) et ceux de six ans (cinq anneaux d'hiver) prédominent ici encore dans chaque lot, comme dans le groupe I. Comparativement aux harengs de quatre et six ans, les harengs de cinq ans (quatre anneaux) sont, ici aussi, mal représentés.

Dans cette région sise au Sud de l'embouchure de la Somme, comme dans la première sise au Nord, les harengs de quatre ans (trois anneaux) dominent en début de saison et leur pourcentage va ensuite en diminuant jusqu'à la fin de Janvier. Les harengs de six ans (cinq anneaux) sont également relativement nombreux dès Novembre, diminuent légèrement en Décembre et augmentent en Janvier. Ceux de cinq ans (quatre anneaux) sont en plus grand nombre dans le courant de Décembre (Lot II) et diminuent légèrement ensuite. Les jeunes harengs de trois ans (deux anneaux) présentent, enfin, leur maximum pendant les deux premiers mois et diminuent sensiblement en Janvier, fin de la saison.

En résumé, dans cette zone comme dans la précédente, on peut constater que les bancs sont constitués par des individus plus âgés à mesure que s'avance la saison.

Ici, comme dans la première zone, la ponte de chaque classe est d'autant plus tardive que les harengs sont plus âgés, et, l'âge moyen de chaque lot nous donne pour le groupe II:

Lot I ..... 4 ans 03
Lot II ..... 4 ans 42
Lot III ..... 4 ans 51

chiffres légèrement inférieurs à ceux constatés pour le groupe I, mais expliquant encore l'augmentation de la taille moyenne constatée dans chacun des lots successifs du Groupe II.

Ces conclusions tirées de l'étude du matériel de 1928 viennent confirmer celles énoncées précédemment pour le matériel de 1927 prélevé dans la même région.

Vertèbres.

Un seul lot a été constitué avec les harengs prélevés dans la zone située au Sud de la Somme, pour l'étude des vertèbres. Les résultats obtenus ont été les suivants:

| Vertèbres | Fréquence |
|---|---|
| 54 | 0 |
| 55 | 2 |
| 56 | 64 |
| 57 | 128 |
| 58 | 22 |
| 59 | 1 |
| | — |
| $n$ = | 217 |
| Mode = | 57 |
| Moyenne = | 56,798 |
| Indice de variabilité: $\sigma$ = | $\pm$ 0,64 |
| Fluctuation probable de la moyenne: $Fl$ = | $\pm$ 0,145 |

On peut constater, par les chiffres précédents, que la moyenne du nombre total de vertèbres (moyenne vertébrale) des harengs constitutant le Groupe II (de l'embouchure de la Somme à Antifer) est sensiblement différente de la moyenne vertébrale obtenue pour les harengs du Groupe I (de Gris Nez à l'embouchure de la Somme).

Les graphiques des figures 2 et 3 montrent la répartition du nombre de vertèbres et la fluctuation de ce caractère dans chacun des groupes étudiés.

Le polygone de variation du Groupe II montre une répartition différente avec une variabilité plus faible que le polygone de variation du Groupe I. De plus, les triangles représentatifs de la fluctuation du nombre de vertèbres de chaque Groupe n'empiétant pas l'un sur l'autre, on peut conclure que les deux Groupes I et II sont constitués par des populations absolument distinctes quant au caractère considéré.

Or, ce caractère est considéré par la grande majorité des ichthyologistes comme un critérium distinctif des différentes populations harenguières. Nous devons donc admettre que: d'Octobre à Janvier, à l'entrée Orientale de la Manche, deux populations harenguières distinctes se rassemblent pour la ponte. Une première, correspondant à notre Groupe I, et que nous pouvons admettre comme faisant partie de la population de la partie Sud de la Mer du Nord (Southern North Sea Type. Hodgson & le Gall) et dont la limite méridionale, d'ailleurs plus ou moins variable, s'établirait de l'embouchure de la Somme au Sud des Battures et de la Queue du Vergoyer.

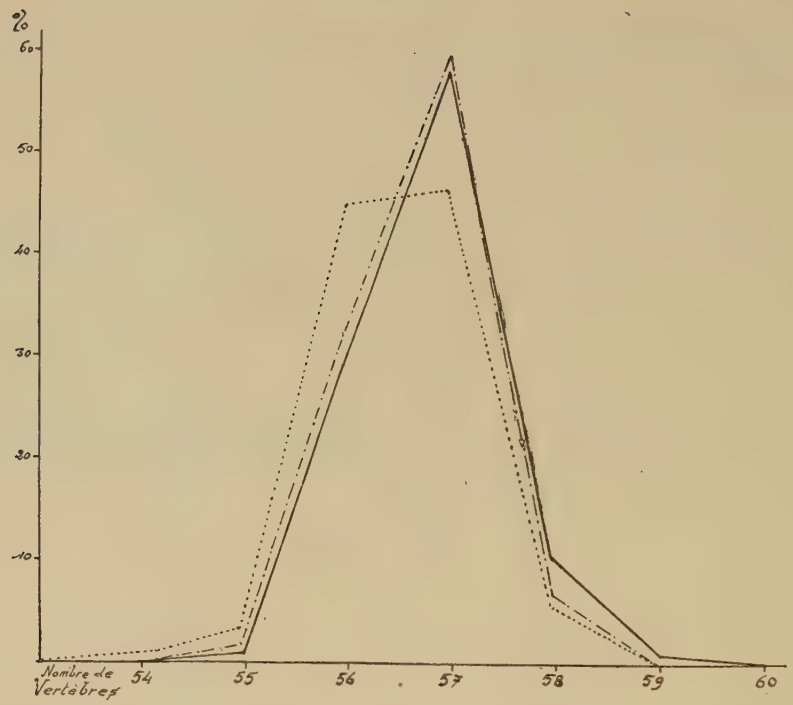



Fig. 2. Polygones de variation du nombre de vertèbres des Harengs de la Manche Orientale.
Groupe I ----------. Groupe II ——————. Groupe III —·—·—·—.

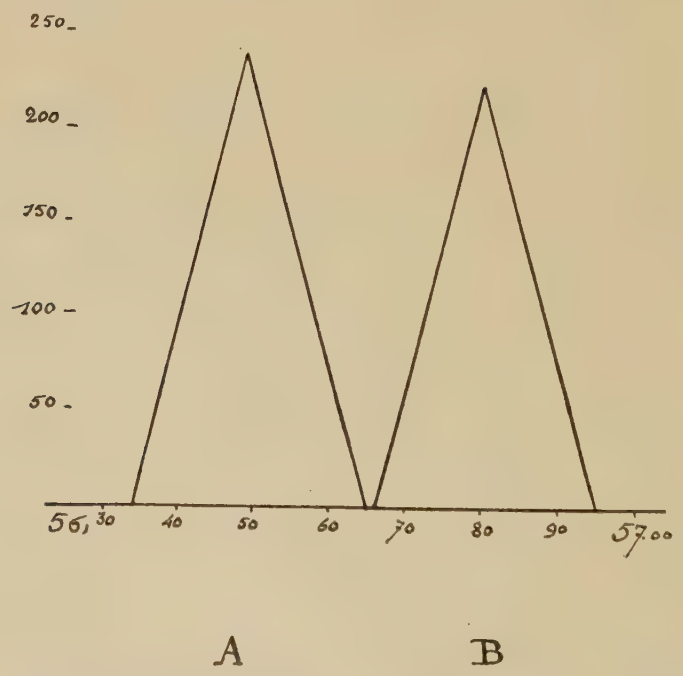



Fig. 3. Triangles représentatifs des fluctuations du nombre de vertèbres.
A. Harengs du Groupe I. B. Harengs du Groupe II.

Correspondant à notre Groupe II, existerait une deuxième population s'étendant au Nord jusqu'à l'embouchure de la Somme (tout au moins à l'époque considérée) et qui se rattacherait très probablement à la variété dite de la Manche (Channel Sea Type) rencontrée à la même époque sur les pêcheries de Plymouth et de Brixham et dont la moyenne vertébrale (Orton: 56,77 — Schnakenbeck: 56,85 — Ford: 56,78 (Plymouth), 56,74 (Brixham) — le Gall: 56,785) est sensiblement la même.

Cette population du Groupe II peut se caractériser ainsi: au moment de la période de rassemblement pour la ponte dans la région comprise entre l'embouchure de la Somme et le Cap d'Antifer:

Taille moyenne calculée sur le lot total:

25 centimètres 63.

avec les classes dominantes: 25..... 29,9 %
26..... 26,2 %
24..... 25,6 %

Au début de la saison, Novembre, les harengs de petite taille, au dessous de 25 centimètres, sont sensiblement plus nombreux, la taille s'élève ensuite sensiblement et les harengs au dessus de 25 centimètres dominent à leur tour.

Au point de vue âge:

Les harengs de six ans (5 anneaux d'hiver) dominent nettement: 31,2 %, puis viennent les harengs de quatre ans (3 anneaux d'hiver) 29,2 %, les harengs de cinq ans (quatre anneaux) mieux représentés que dans le Groupe I: 16,3 % et les harengs de sept ans (6 anneaux): 16,0 %.

Les jeunes harengs de trois ans (2 anneaux), sont encore en faible quantité, mieux représentés toutefois que dans le groupe précédent: 4,5 %. Ils seront encore mal représentés dans la population harenguière de 1929 dans cette région, population qui présentera, par conséquent, une faible proportion de harengs de quatre ans (3 anneaux en 1929), avec au contraire, une forte proportion de harengs de cinq ans (4 anneaux en 1929) et de harengs de sept ans (6 anneaux en 1929).

La taille moyenne observée donne pour ces harengs du Groupe II:

| | |
|---|---|
| 3 ans (2 anneaux)..... 23 cms 54 | 6 ans (5 anneaux)..... 25 cms 91 |
| 4 ans (3 anneaux)..... 24 cms 25 | 7 ans (6 anneaux)..... 26 cms 50 |
| 5 ans (4 anneaux)..... 25 cms 39 | 8 ans (7 anneaux)..... 26 cms 80 |

tailles légèrement supérieures à celles observées pour les harengs du Groupe I et d'âge correspondant.

**Moyenne vertébrale: 56,798** $\sigma = \pm 0{,}64$ $Fl = \pm 0{,}145$

### Groupe III.

Détroit de Douvres: du South Foreland à Beachy Head.

Un groupe spécial a été constitué avec une série d'échantillons prélevés en Décembre et Janvier, au large de la côte anglaise, entre le South Foreland et Beachy Head (Kent et Sussex)

Au cours de la saison harenguière 1928—1929, la pêche fut relativement bonne dans cette région, et un certain nombre de drifters boulonnais la fréquentèrent pendant les mois de Décembre et (surtout) de Janvier; le gros de la pêcherie restant cependant plus dans l'Est ou le Sud Est sur les lieux habituellement fréquentés de la côte Est de la Manche Orientale. Ils constituèrent donc une pêcherie en dehors de la zone habituelle. Cette raison, liée à d'autres raisons d'ordre hydrographique, nous incita à constituer un groupe distinct avec les harengs provenant de cette région.

Il est de toute évidence que l'on se trouve ici encore dans une région de ponte, la majorité des harengs étant au Stade VI vers la mi-Décembre[1]).

## Taille.

La répartition par taille s'établit ainsi:

| Centimètres | 22 | 23 | 24 | 25 | 26 | 27 | 28 | Taille moyenne |
|---|---|---|---|---|---|---|---|---|
| Groupe III....% | .. | 9,6 | 20,7 | 22,7 | **29,0** | 14,5 | 3,4 | 25,78 |

montrant que les poissons de 25 centimètres et au dessus dominent dans le groupe.

## Age.

La répartition par âge donne:

| Anneaux d'hiver | 2 | 3 | 4 | 5 | 6 | 7 | 8 | plus de 8 |
|---|---|---|---|---|---|---|---|---|
| Groupe III....% | 3,4 | **37,2** | 4,8 | 18,6 | **28,3** | 6,9 | 0,7 | .. |

Age moyen du lot: 4 ans 54.

## Vertèbres.

La moyenne vertébrale établie sur cinquante individus a donné les chiffres suivants:

| Vertèbres | Fréquence |
|---|---|
| 55 | 1 |
| 56 | 16 |
| 57 | 30 |
| 58 | 3 |

$n = 50$

Moyenne $= 56{,}70$

Indice de variabilité: $\sigma = \pm 0{,}67$

Fluctuation probable de la moyenne: $Fl = \pm 0{,}32$

[1]) Signalée d'ailleurs par W. C. Hodgson. Some spawning Places of the Herring of the Southern North Sea. Journal du Conseil. Volume III. No. 2, pp. 220.

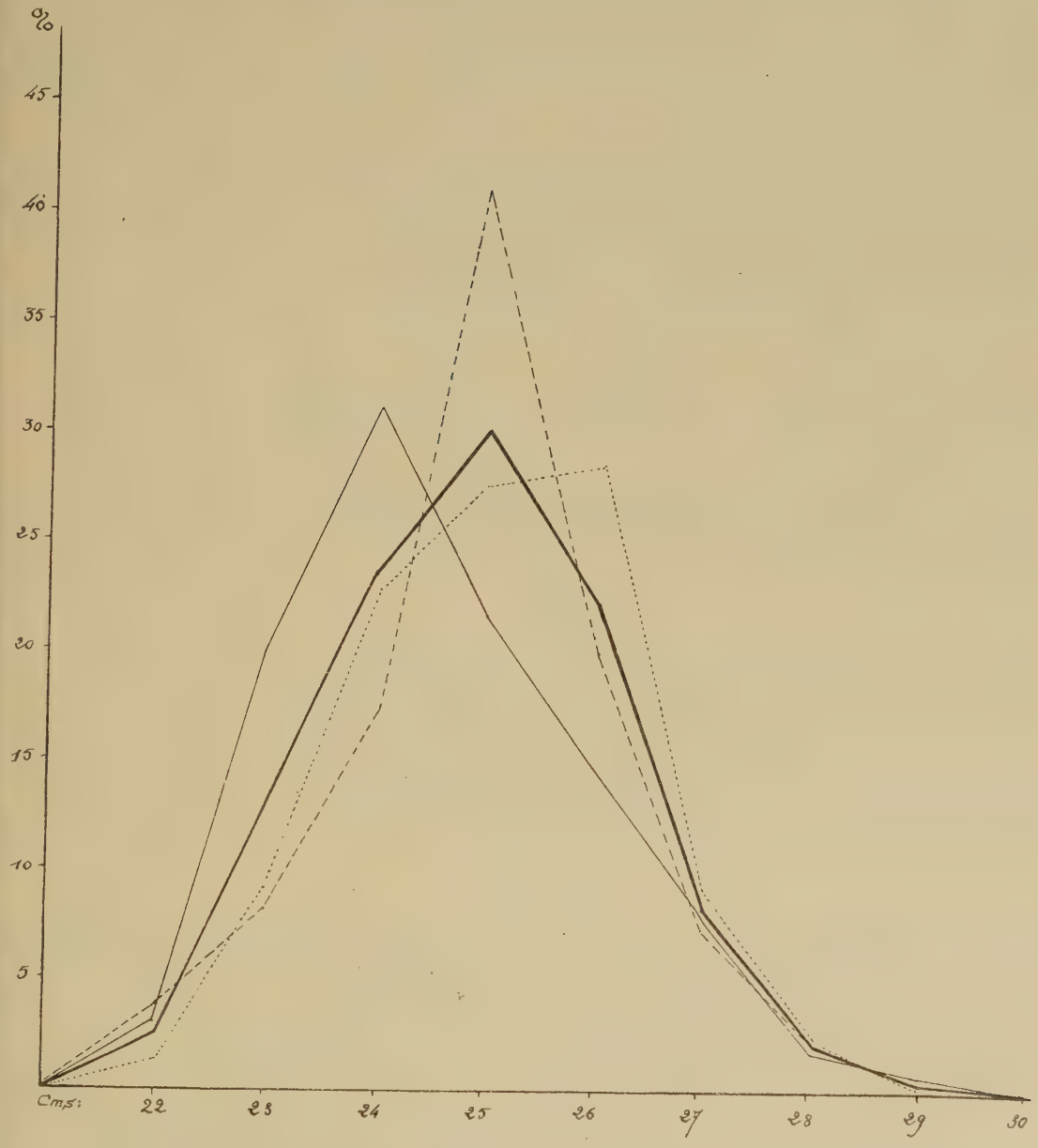



Fig. 4. Polygones de variation de la taille des Harengs en Manche Orientale.
1926 ————. 1927 — — — —. 1928 ----------. Moyenne des trois années ————.

Cette moyenne vertébrale se rapproche d'avantage de la moyenne obtenue pour notre Groupe II: 56,798, que de la moyenne du Groupe I: 56,50. Elle correspond de plus à celle donnée par E. Ford pour les harengs de la côte du Sussex: 56,70. Il y aurait donc lieu de rattacher, de préférence, ces harengs capturés au large de la côte anglaise de la Manche orientale en Décembre 1928, à la population propre de la Manche (Channel Sea Type).

Leur répartition par âge montre une prédominance de harengs de quatre ans (3 anneaux d'hiver): 37,2 % et de harengs de sept ans (6 anneaux) 28,3 %. Les harengs de six ans (5 anneaux) sont moins bien représentés que dans les groupes précédents: 18,6 %, et l'on peut constater encore une très faible proportion de harengs de cinq ans (4 anneaux) 4,6 % et de trois ans (2 anneaux) 3,4 %.

La taille observée correspondant aux différents âges est la suivante pour ce groupe:

| | |
|---|---|
| 3 ans (2 anneaux..... | 23 cms 0 |
| 4 ans (3 anneaux..... | 24 cms 33 |
| 5 ans (4 anneaux..... | 25 cms 71 |
| 6 ans (5 anneaux)..... | 25,81 |
| 7 ans (6 anneaux)..... | 26,05 |
| 8 ans (7 anneaux)..... | 26,50 |

moyenne supérieure pour les jeunes classes (quatre et cinq ans) à la moyenne observée dans les Groupes I et II, et intermédiaire entre ces moyennes pour les classes plus agées (plus de cinq ans).

## Considérations sur la population harenguière en Manche Orientale pendant la saison 1928—1929.

Pour avoir des résultats comparables à ceux des années précédentes, nous considèrerons, tout d'abord, cette population en bloc et étudierons sa répartition au point de vue taille et âge au cours de la saison toute entière.

### Taille.

La répartition des individus, par taille, a donné les résultats suivants, comparés pour mémoire avec les résultats de 1926 et 1927 (Fig. 2).

| Centimètres..... | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | [1]) Taille moyenne |
|---|---|---|---|---|---|---|---|---|---|
| Année 1926—27.....% | 2,9 | 20,2 | **31,0** | 21,5 | 14,5 | 7,8 | 1,6 | 0,4 | 24,34 |
| Année 1927—28.....% | 3,6 | 8,2 | 17,0 | **41,0** | 20,0 | 7,4 | 2,2 | 0,4 | 24,92 |
| Année 1928—29.....% | 1,3 | 9,1 | 22,4 | 27,2 | **28,2** | 9,1 | 2,3 | 0,1 | 25,07 |
| Moyenne des 3 années...% | 2,6 | 12,5 | 23,4 | 29,9 | 20,9 | 8,1 | 2,0 | 0,3 | 24,77 |

[1]) Taille à majorer de 0,50 pour avoir la taille moyenne vraie.

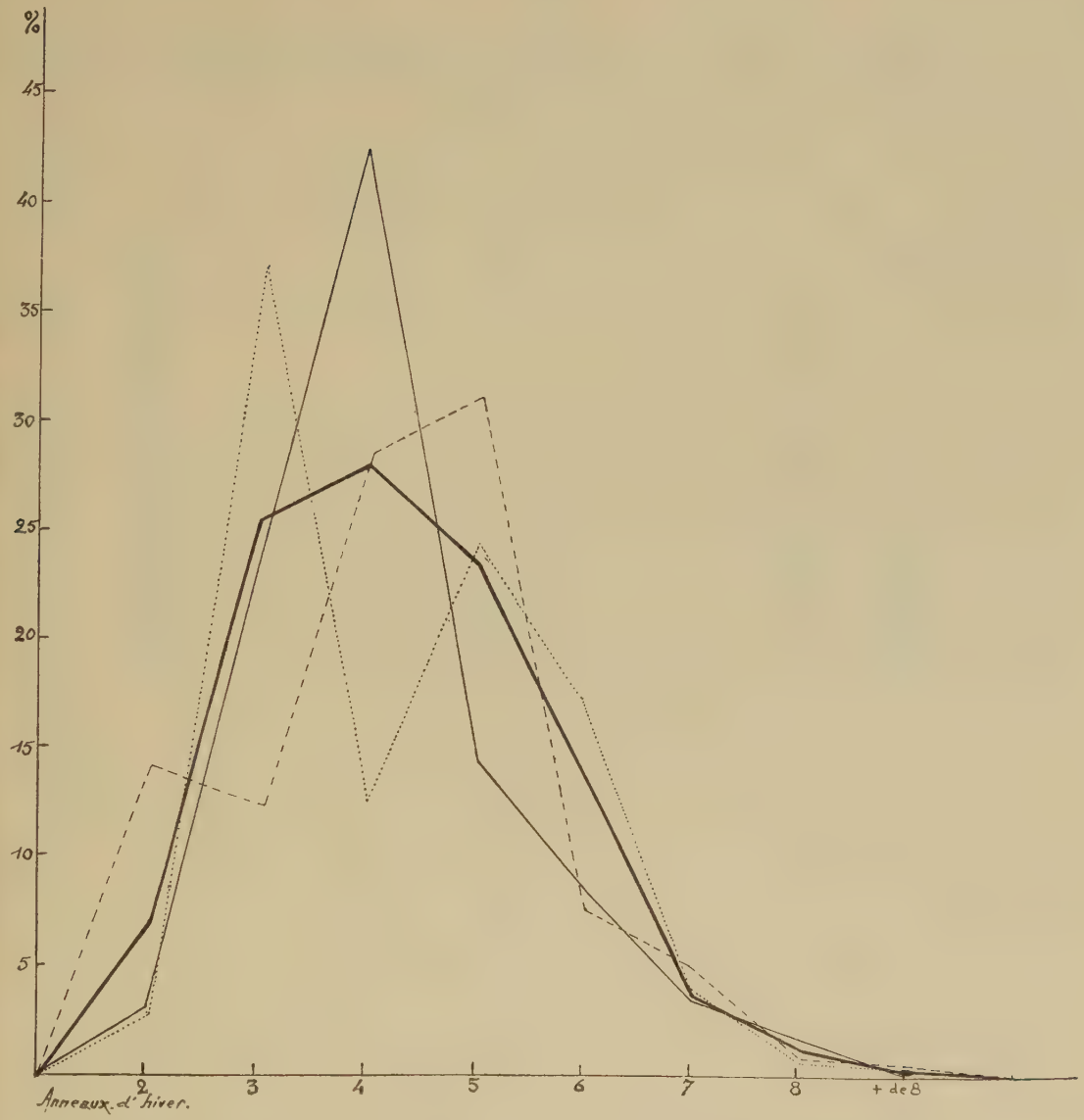



Fig. 5. Polygone de variation de l'âge des Harengs en Manche Orientale.
Stock de 1926 ————. Stock de 1927 ————. Stock de 1928 ----------.
Moyenne des trois années ————.

D'après ces chiffres, on peut constater que la répartition des jeunes classes (au point de vue taille) et jusqu'à 25 centimètres inclus, a été légèrement plus faible en 1928 que la répartition moyenne des trois dernières années. Au contraire, la répartition des classes au dessus de 25 centimètres a été plus forte.

La forte classe: taille 24, de 1926—27 se retrouve dans la classe 25 en 1927—28 et domine encore dans la répartition de l'année 1928—29 dans la classe 26.

Age.

La répartition d'après l'âge s'établit ainsi, comparée encore aux années précédentes (Fig. 5).

| Anneaux d'hiver..... | 2 | 3 | 4 | 5 | 6 | 7 | 8 | plus de 8 |
|---|---|---|---|---|---|---|---|---|
| Année 1926—1927 .....% | 3,4 | 26,2 | **42,4** | 14,4 | 8,5 | 3,4 | 1,6 | .. |
| Année 1927—1928 .....% | **14,0** | 12,4 | 28,6 | **31,4** | 7,6 | 4,6 | 0,9 | 0,6 |
| Année 1928—1929 .....% | 3,0 | **37,5** | 12,8 | **24,5** | 17,2 | 3,9 | 0,9 | 0,1 |
| Moyenne des 3 années...% | 6,8 | 25,4 | 27,9 | 23,4 | 11,1 | 3,9 | 1,1 | 0,2 |

La population harenguière dans l'ensemble de la Manche Orientale se caractérise ainsi au cours de la saison 1928—1929, par une forte proportion de harengs de quatre ans (3 anneaux d'hiver) et de harengs de six ans (5 anneaux d'hiver). La forte proportion de harengs de 4 ans rencontrée en 1928 a son origine dans la présence en quantités relativement abondantes (nettement au dessus de la moyenne des trois dernières années en 1927—28), de jeunes harengs de 3 ans (2 anneaux d'hiver: nés en 1924); de même que la proportion élevée de harengs de six ans (5 anneaux) s'explique par le pourcentage élevé des harengs de cinq ans (4 anneaux) en 1927, et retrouvé encore dans les harengs de quatre ans (3 anneaux: nés en 1922), en 1926. En l'absence de chiffres exacts (moyennes basées sur un nombre insuffisant d'exemplaires) il ne nous est permis que de supputer qu'en 1925—26, la proportion de jeunes harengs de 3 ans (2 anneaux: nés en 1922), jeune classe venant reconstituer le stock, fut sensiblement supérieure à la moyenne (Fig. 6).

La saison 1926—1927 fut au contraire déficitaire au point de vue renouvellement du stock de jeunes harengs (3,4 % harengs de 3 ans (2 anneaux: nés en 1923), la moyenne étant 6,8) et ce déficit se retrouve successivement au cours des saisons 1927—28 pour les harengs de 4 ans (3 anneaux), et 1928—29 pour les harengs de 5 ans (4 anneaux) qui sont relativement mal représentés en ces deux années.

Les harengs de sept ans (6 anneaux) dont la proportion apparaît au dessus de la moyenne au cours de la saison 1928—29 se suivent également dans les années précédentes: classe 5: 31,4 % en 1927—28, classe 4: 42,4 % en 1926—27, laissant penser à une forte classe 3 en 1925—26, provenant également d'une abondance de jeunes harengs de 3 ans (2 anneaux: nés en 1921) dans la population de 1924—25 en Manche Orientale.

La faible proportion de harengs de 3 ans (2 anneaux) constatée en 1928—29 se traduira donc par une mauvaise représentation de la classe 3 (4 ans) au cours de la saison prochaine 1929—1930. La classe 4 (5 ans) sera au contraire fortement représentée et dominera très probablement; tandis que la classe 5 (6 ans) sera également déficitaire du fait de la pénurie de harengs de cinq ans (4 anneaux) en 1928—29. La classe 5 (6 ans), bien représentée en 1928—29, sera encore prépondérante dans la population de 1929—30 avec un an de plus (7 ans) et par conséquent classe 6; et la classe 7 (classe 6 de 1928—29) restera enfin au dessus de la moyenne. Les résultats de la prochaine saison viendront infirmer ou confirmer ces prévisions quant à la répartition de la population

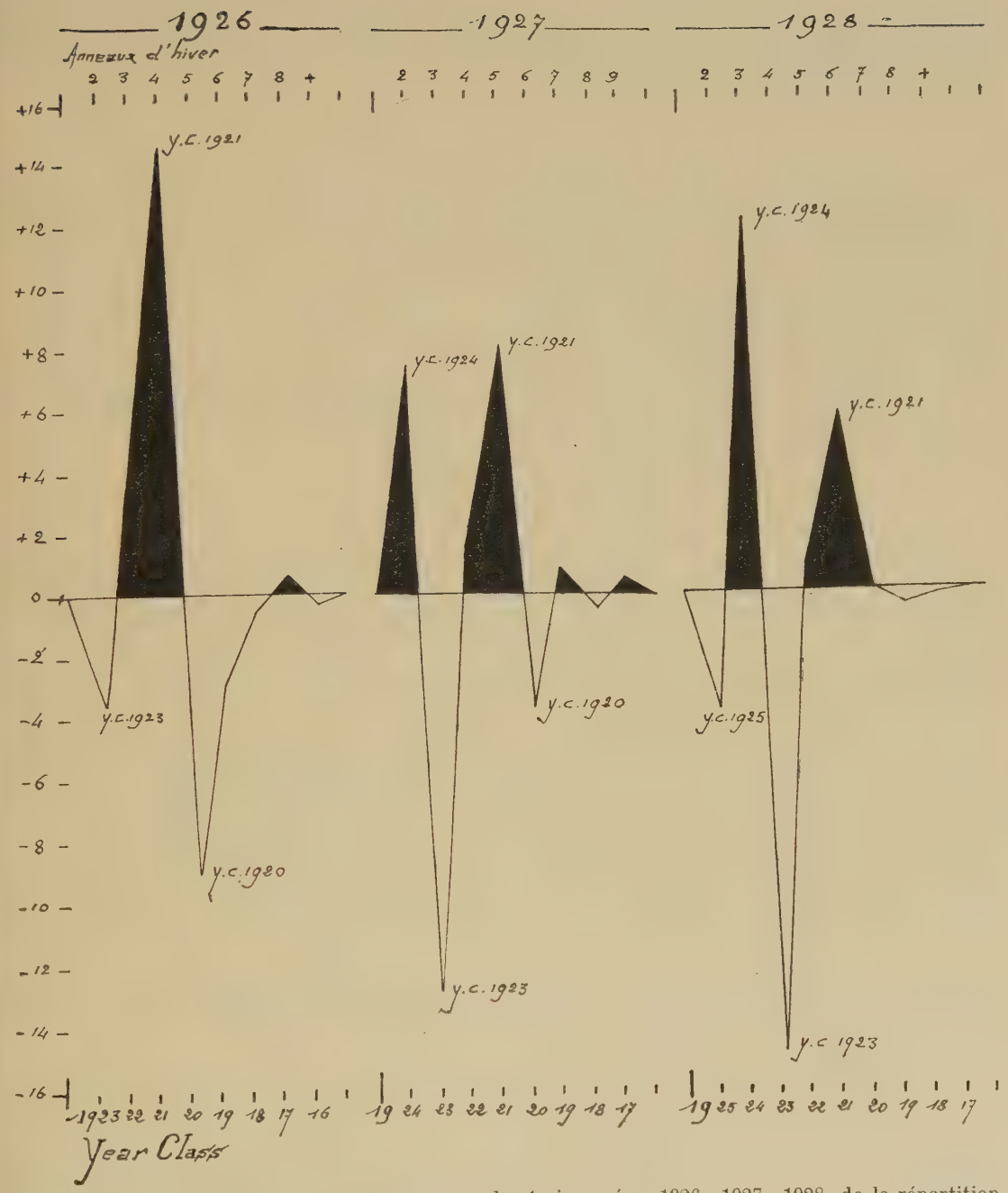



Fig. 6. Fluctuations, par rapport à la moyenne des trois années: 1926—1927—1928, de la répartition par âges de la population harenguière en Manche Orientale, au cours des années 1926, 1927 et 1928.

harenguière en Manche Orientale. Ils permettront de contrôler la valeur de la méthode de travail employée qui n'est pas exempte de toute critique. Nous constaterons toutefois que nos prévisions pour la saison 1928—1929 se sont trouvées exactement confirmées par les résultats des travaux de l'année[1]).

Il convient maintenant d'examiner ce matériel non plus en bloc, mais en tenant compte de la distinction que nous avons faite et isolant, dans la succession de bancs de harengs se pressant pour la ponte, en Manche Orientale, deux populations:

une, correspondant au "Southern North Sea Type": harengs du Sud de la Mer du Nord et retrouvée dans notre Groupe I.

l'autre, pouvant être rattachée au "Channel Type" ou Hareng de la Manche et correspondant à nos Groupes II et III. Ce dernier groupe pouvant être réuni au Lot II du Groupe II prélevé pendant la même période.

### Groupe I.

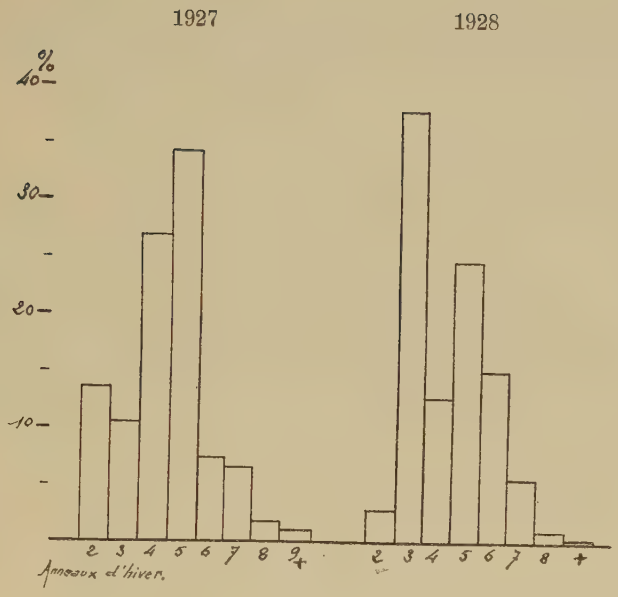
Nous avons déjà fait remarquer que dans ce groupe la proportion de jeunes individus (4 ans) présents sur les fonds de ponte, était plus forte au début qu'en fin de saison, et, qu'au contraire, les individus plus âgés devenaient relativement plus nombreux à mesure que s'avançait cette saison; autrement dit: que la ponte était, d'une façon générale, plus tardive avec l'âge. Observations venant confirmer celles déjà émises par nous, sur ce sujet, pour 1927.

En comparant les résultats obtenus en 1928 au point de vue âge, avec les résultats précédemment obtenus en 1927[2]) on peut remarquer que la forte proportion de harengs de quatre ans (3 anneaux) en 1928 a son origine dans l'abondance relative de harengs de trois ans (2 anneaux) en 1927, que la pénurie de harengs de cinq ans (4 anneaux) provient de la mauvaise représentation des harengs de quatre ans (3 anneaux) dans le stock de 1927; que l'abondance de harengs de six ans (5 anneaux) en 1927, se manifeste par une représentation élevée des harengs de sept ans (6 anneaux) en 1928. Autrement

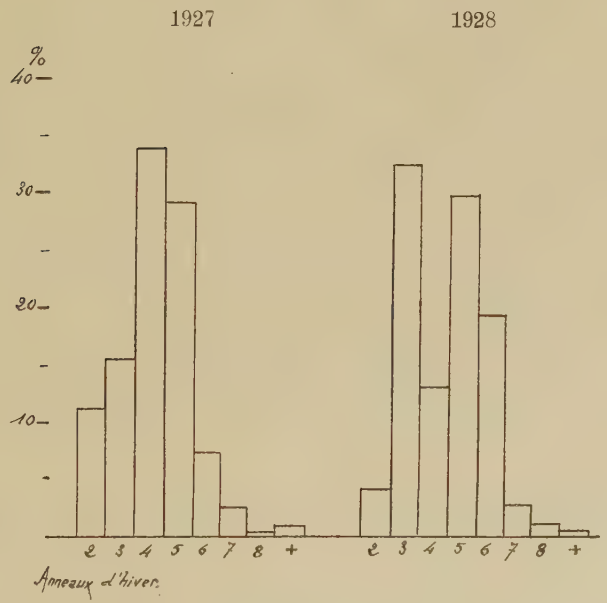
[1]) J. Le Gall. Remarques et Statistiques biologiques sur les Harengs de la Mer du Nord, de la Manche et de l'Atlantique. Matériel de 1927. Revue des Travaux de l'Office Scientifique et Technique des Pêches. T. I. No. I., p. 48, 1928.

[2]) Voici pour mémoire ces résultats:

| Anneaux d'hiver | 2 | 3 | 4 | 5 | 6 | 7 | 8 | plus de 8 |
|---|---|---|---|---|---|---|---|---|
| Lot I. 28. X—14. XI....% | 20,0 | 13,5 | 25,8 | 25,8 | 8,5 | 5,0 | 1,3 | .. |
| Lot II. 21. XI—5. XII....% | 8,8 | 8,8 | 28,0 | 33,3 | 7,0 | 10,5 | 1,7 | 1,7 |
| Lot III. 2—11. I....% | 10,9 | 8,5 | 24,4 | 43,9 | 6,1 | 3,6 | 1,2 | 1,2 |
| Moyenne des 3 lots...% | 13,2 | 10,2 | 26,1 | 34,1 | 7,2 | 6,4 | 1,4 | 1,0 |




Groupe I.




Groupe II.

Fig. 7. Répartition, d'après l'âge, de la population harenguière en Manche Orientale pendant les années 1927 et 1928.

dit: dans ce Groupe I la répartition des individus par âge est influencée par: la présence abondante de harengs nés: en 1921 et en 1924 et la présence déficitaire de harengs nés: en 1920, 1923 et enfin (pour 1928) en 1925 (Fig. 7, Groupe I).

### Groupe II.

Dans ce groupe également, en 1928 comme en 1927, la ponte s'est montrée plus tardive avec l'âge. Il est d'ailleurs à remarquer qu'à âge égal, dans ce groupe, elle est légèrement en retard sur le Groupe I d'une dizaine de jours environ.

En rattachant le Groupe III au Groupe II — ce qui paraît logique puisque nous avons montré le rapprochement des harengs de ces deux groupes avec le Channel Type — nous obtenons dans le calcul des moyennes pour l'année 1928 des résultats légèrement différents de ceux obtenus pour le Groupe II et le Groupe III considérés isolément. Ces résultats sont les suivants:

| Anneaux d'hiver | 2 | 3 | 4 | 5 | 6 | 7 | 8 | plus de 8 |
|---|---|---|---|---|---|---|---|---|
| Lot I .....% | 5,5 | **41,7** | 8,3 | **33,3** | 11,1 | .. | .. | .. |
| Lot II combiné avec Groupe III.% | 4,4 | **32,6** | 10,7 | 21,8 | **23,2** | 5,3 | 1,8 | .. |
| Lot III .....% | 1,6 | **21,9** | 19,1 | **32,4** | 23,0 | 1,2 | 0,8 | .. |
| Moyenne des trois lots...% | 3,8 | **32,1** | 12,7 | **29,2** | 19,1 | 2,2 | 0,8 | .. |

La prédominance des classes 3 et 5 apparaît toutefois nettement comme dans les Groupes I ou II. La classe 6 est également fortement représentée. Les classes 2 et 4 sont au contraire déficitaires. En comparant ces chiffres de 1928 avec ceux trouvés en 1927[1]), on retrouve encore dans ce groupe l'influence marquée de diverses "Year Classes" comme dans le groupe précédent. Les années 1921, 1922, 1924 sont ici aussi prépondérantes tandis que les années 1923 et 1925 apparaissent déficitaires (Fig. 7, Groupe II).

Il est curieux de constater l'influence prépondérante des mêmes années de ponte dans la répartition au point de vue âge de deux populations évidemment voisines à l'époque des rassemblements de ponte, mais néanmoins distinctes tant par leur origine (Type de la Manche et Type de la Mer du Nord) que par les régions différentes qu'elles occupent au moment de leur période de dispersion trophiques.

[1]) Résultats obtenus en 1927 pour le Groupe II:

| Anneaux d'hiver | 2 | 3 | 4 | 5 | 6 | 7 | 8 | plus de 8 |
|---|---|---|---|---|---|---|---|---|
| Lot I. 2—18 XI .....% | 14,6 | 17,0 | 31,3 | 19,4 | 7,3 | 7,3 | .. | 2,5 |
| Lot II. 10—21 XII.....% | 3,3 | 21,6 | 41,5 | 28,2 | 5,0 | .. | .. | .. |
| Lot III. 12—18 I .....% | 16,2 | 6,9 | 27,9 | 39,5 | 9,3 | .. | .. | .. |
| Moyenne des 3 lots...% | 11,4 | 15,2 | 33,6 | 29,0 | 7,2 | 2,4 | .. | 0,8 |

## Résumé et Conclusions pratiques.

Le matériel étudié, provenant de la Manche Orientale, a été régulièrement prélevé pendant toute la durée et sur toute l'étendue de la pêcherie harenguière en Manche Orientale, et rassemblé par lots et groupes suivant les époques et les lieux de pêche. Ces lots et groupes ont été étudiés séparément d'abord, puis comparativement les uns aux autres puis enfin rassemblés pour une étude globale portant sur ces trois dernières années.

Des résultats obtenus, on peut conclure:

Les rassemblements observés en Manche Orientale sont des rassemblements de ponte, quelque soit le groupe examiné, de fin d'Octobre à fin Janvier.

Dans chacun de ces groupes, la ponte a lieu d'abord pour les jeunes classes qui dominent dans les rassemblements du début de la saison, puis ensuite pour les classes de plus en plus âgées.

La répartition des individus par âge, aussi bien dans les groupes que dans l'ensemble de la population de la Manche Orientale, montre l'influence prépondérante de plusieurs années de ponte:

années abondantes: 1921—1922—1924.
années déficitaires: 1923—1925.

Cette influence se traduira encore dans la répartition des individus au cours de la saison de 1929 par:

une abondance relative d'individus de cinq ans (4 anneaux d'hiver), de sept ans (6 anneaux d'hiver) et probablement de huit ans (7 anneaux d'hiver).
une disette relative d'individus de quatre ans (3 anneaux) et de six ans (5 anneaux).

L'examen du nombre de vertèbres dans chaque groupe montre l'origine différente de ces groupes:

Le Groupe I dont l'extension couvre la région de Gris Nez à l'embouchure de la Somme et dont la moyenne vertébrale est 56,50 $\pm$ 0,15, peut être rattaché au Southern North Sea Type.

Les Groupes II et III répartis dans la région comprise de l'embouchure de la Somme au voisinage d'Antifer (Groupe II), puis à quelques milles au large de la côte anglaise de Sussex et du Kent (Groupe III), dont la moyenne vertébrale est 56,80 $\pm$ 0,14 (Groupe II) et 56,70 $\pm$ 0,32 (Groupe III) peuvent être rattachés au Channel Type (Harengs de la Manche).

L'origine distincte de ces groupes fait que toute condition hydrologique pouvant influencer l'importance et la répartition d'un de ces groupes peut être sans action directe sur l'autre groupe, autrement dit les résultats de la pêche dans la région de Boulogne (Harengs du Sud de la Mer du Nord) ne permettent pas de prévoir quels pourront être les résultats de la pêche, un peu plus tard, dans la région de Dieppe (Harengs de la Manche).

La présence, au large des côtes anglaises du Sussex et du Kent, de harengs appartenant au type de la Manche, laisse prévoir que ce type doit pouvoir s'étendre plus loin jusqu'en Mer du Nord. L'examen du matériel recueilli méthodiquement dans la

région du Dyck et du Sandettié, au Sud de la Mer du Nord, permettra de vérifier ce fait[1]).

Enfin, les apparitions et disparitions périodiques des bancs de harengs déterminant les déplacements réguliers dans l'ensemble de la pêcherie établie en Manche Orientale, (Apparition des harengs de la St. Martin (vers le 11 Novembre), de la St. Nicolas (6 Décembre) laissent prévoir encore que ce rythme n'est pas sans relations avec le rythme régulier des transgressions et régressions des eaux à 35 $^0/_{00}$[2]) dans cette région et il y a tout lieu de penser qu'une étude suivie de ce rythme permettrait de déterminer à l'avance les zones probables des rassemblements de ponte et par suite de bonne pêche.

Ces quelques résultats montrent, enfin, l'avantage de la méthode employée dans nos prélèvements d'échantillons. Il apparaît nettement, en effet, que des prélèvements faits à des endroits ou à des époques quelconques dans la région étudiée eussent donné des résultats tout à fait différents quant à la répartition des individus au point de vue taille ou âge, suivant la date des prélèvements et des conclusions également différentes quant à l'origine des populations harenguières en Manche Orientale suivant le lieu où ces prélèvements auraient été effectués.

Par celà même, la nécessité de prélèvements fréquents et réguliers devient évidente.

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[1]) Matériel actuellement à l'étude.

[2]) On se rappellera que les bancs de harengs semblent fuir ces eaux salées et qu'ils se tiennent à leur limite sans y pénétrer (Le Danois).

# XIX. Fluctuations in the Stock of Young Sprat off the West Coast of Norway and its Relation to the Sprat Population as a whole.

By

**Paul Bjerkan.**

The sprat fishing districts of Norway are divided into two areas, a smaller eastern one, the Oslofiord and environs, and a larger western one, from the Naze to Statland and even further north to Trondhjemsfiord.

The sprat is found in the intervening districts too, but the fishery is insignificant owing to the configuration of the coast and the lack of fiord systems.

The most lucrative fishing districts are the fiords of Ryfylke and Sunnhordland, which latter might be said to be the centre of the sprat fishing districts of the west coast.

North of Statland mostly mixed schools, sprats and young herrings, are found, and this fact I must ask you to bear in mind. Some years, however, very good catches have been made as far north as Molde.

In fig. 1 the distribution of the yield of the sprat fishery along the coast is shown as an average of 20 years (1908—27).

The yield of the sprat fishery displays large fluctuations as shown in fig. 2. Some of the fluctuations shown are, however, caused by technical improvements, such as the use of the purse seine since about 1908 and new activities as the increase in the fishery of the eastern area since 1923.

The decrease in the yield, even in periods of extended fishing activities, however, shows that natural conditions, and then most surely fluctuations in the stock are at play too. In this connection I may especially point out the bad fishing seasons 1919 and 1928 and the decrease in the yield from 1912.

The sprat fishery off the west coast of Norway is most decidedly a fishery of a young fish stock. This has been shown by Sund and Koefoed (1908—09), and the fact is accentuated by the recent investigations, in 1920 and onward, which have shown that the one-year-old sprat, the sprat in its second summer, provides the Norwegian sprat fishery with more than 95 % of the yield in ordinary years.

This fact shows that a renewal of almost the whole stock takes place every year, and as there is mostly very little spawning observed along the west coast of Norway,

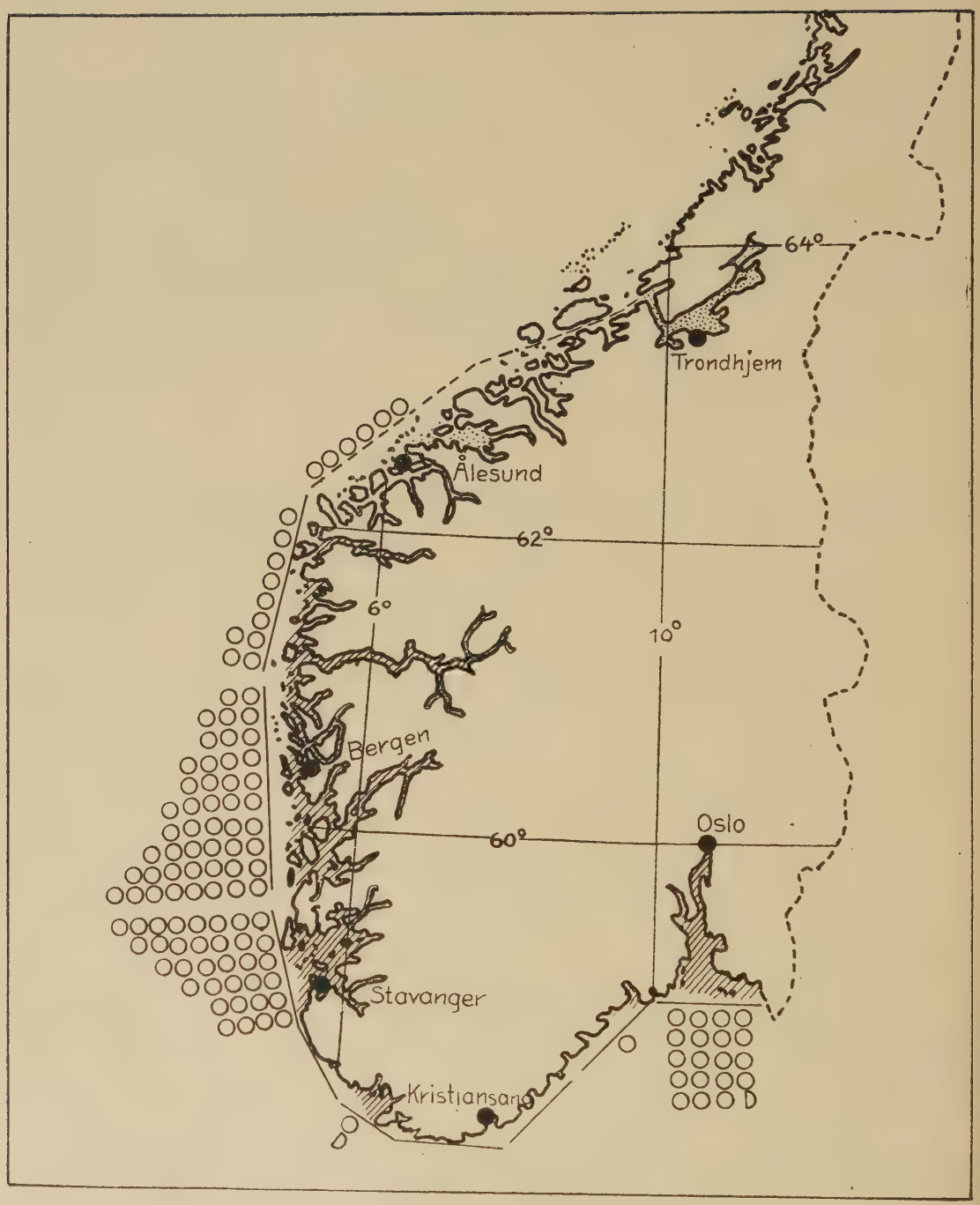


Fig. 1. Sprat Fisheries of Norway.
○ = 1000 hl. catch, average of 20 years 1908—27.

Note: The average yield, 6000 hl., off Aalesund (Möre) is too high which is caused mostly by extraordinary high figures for 1915. According to later interrogations those figures are erroneous and the quantity ought to be reduced with $^1/_3$—$^1/_2$ to 3—4000 hl., which is more in accordance with the yield of recent years.

this renewal must largely be dependent on immigration from the principal spawning districts, the Skager Rack and the North Sea coasts. This gives opportunity to very marked fluctuations.

In order to understand these fluctuations, it is necessary to know how the renewal of the stock is effected.

Some variations in the average size of the sprat from the different districts and in sprats from pure schools and from schools mixed with herrings give some clues.

In schools mixed with young herrings the sprats are larger than the sprats of

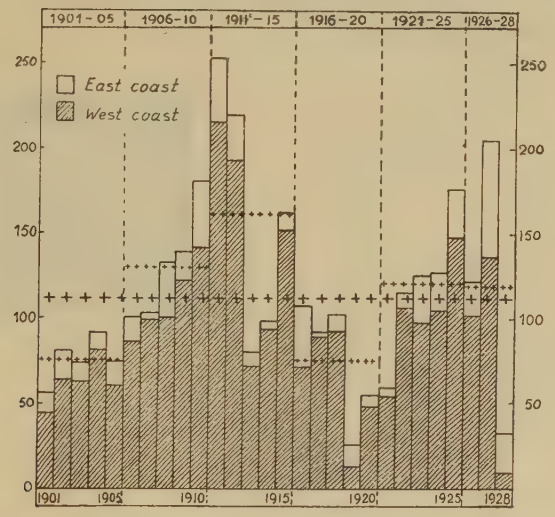


Fig. 2. Sprat Fisheries of Norway. Catch in 1000 hl.
+++ Average of 28 years (1901—28). ..... Average in 5 years' periods.

the same year-class from pure schools. North of Statland where such mixed schools are the rule as well as in pure schools from Northern fiords, the sprats are larger too.

By calculations from the scale readings this is shown to be largely due to variations in the growth during the first summer.

The fiord stock of young sprats is renewed by immigrations during the autumn. Mostly in the first part of September the young fish push into the outer fiord systems and later on further into the deeper fiords. By direct measurement it has been shown that the young fish in the schools are then very variable as to average size and to a great extent that the schools with more developed young fish are found farther north along the coast.

This I have interpreted as showing that the first hatched and more developed young fish have had time to be carried farther away from the spawning places.

That sprats of different age, in weeks and months, are found we know. The sprat has been found spawning between February and September. In this connection I may refer to the investigations of Herrick (1923), who found that the spawning of one sprat might cover $2^1/_2$ month, the sprat spawning in batches with intervals of 8—9 days.

Off the Norwegian coast fry of 15 mm.s length have been found in the middle of March off the south coast, while fry of 25 mm.s length have been found off the west coast in the first part of September. This gives a wide scope as to variation in age of the same year-class and accordingly in size.

Fig. 3 shows a young sprat of 3.5 cm. length and another of 8.5 cm. length from the month of September taken from the same school, the latter with a reproduction of the scale to show that it is a young fish. The one is a baby fish, the other a good-sized sprat.

I may remark that in other years I have found young sprat as large as 9.5 cm. caught during the same month, September. The larger young sprats are thus fully marketable fish in the first autumn at least during some years.

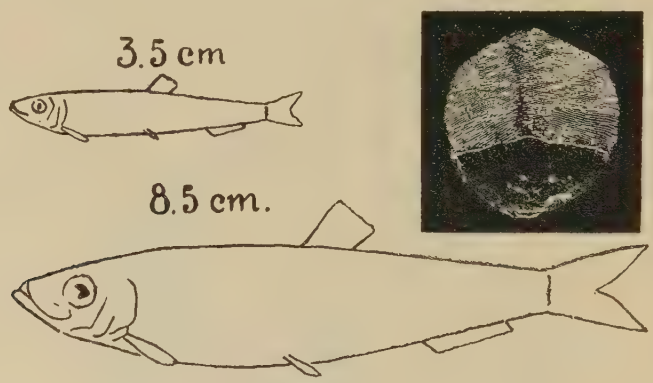


Fig. 3.

Generally speaking I have found that a very variable stock of young sprats are dispersed along the coast according to size and development at the time they push into the fiords.

The oldest and largest young sprats are mostly found in the mixed schools. They arrive in the western coast waters at a time when the young herrings are of about the same size order. They mix and form homogeneous schools, which are to a large extent carried northward with the prevailing current. Later arrivals mostly form the pure sprat schools, with larger, more even young fish in the northern and varied and mostly smaller sprats in the southern parts of the West Norwegian sprat districts.

During the last sprat season a very good material of young sprat was procured. From the month of September, 1928, to January, 1929, in all 29 samples with about 10,000 specimens.

Fig. 4 gives the result as to relative length of the sprat from pure schools and from mixed schools from each month for this collection. As may be seen the sprats from the mixed schools are on an average larger and more developed than those from the pure schools, this is most marked for the month of December with sprats of both categories. The growth is continued up to the month of November. From the month of November and onward no growth is found in any of the categories.

The length-weight relation of sprats from mixed schools and pure schools from

the months of November to January taken for each length group, also confirms the idea that the young sprats from the mixed schools are more developed and, as I take it, older than those from the pure schools as shown in fig. 5.

As stated above the autumn immigration constitutes the fiord stock of young sprat. Most years there is a more or less pronounced spring immigration too. When such an immigration occurs there are mostly runs and rises in the fiord stock as well and good fishing results. The spring immigrants mostly mix with the fiords stock later on and

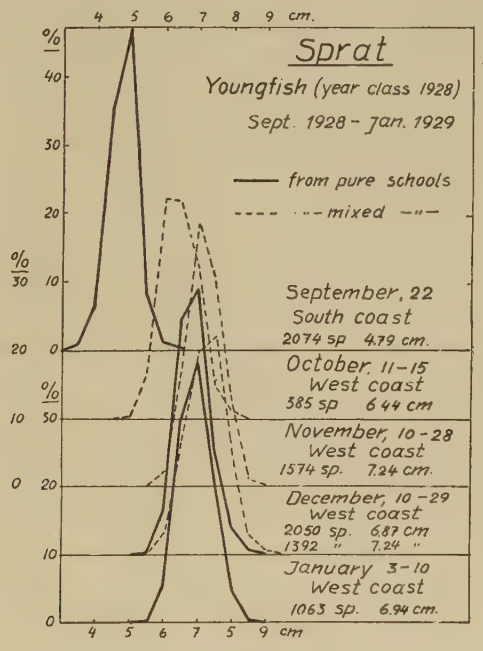


Fig. 4.

this often brings confusion in the size groups and more variation in the whole stock. Generally the spring immigrants are smaller, but the contrary might sometimes be found.

That a fishery depending on such immigrations as sketched above might be subject to fluctuations is easily understood. The fluctuations affect the amount of stock and as might be understood by the facts stated above also the size and development of the sprat.

As stated above the fluctuations in the yield of the fishery shown in fig. 2 are to a considerable extent affected by the developments of the fishery technicalities and the "sardin" industry, even the war situation might be taken in consideration during some years. Some features in the fluctuations must, however, as shown above be taken as indications of real fluctuations in the available stock.

Since the year 1920 the sprat stock along the Norwegian coast has been subject to special investigations of which I have been in charge. Referring to what has been stated before about immigration of young sprat as the principal origin of the stock and

about the special dispersion along the coast by the prevailing currents mostly according to age and size of the individuals of the same year-class, I will in the following try to sketch the conditions of the stock during the years 1920—1928.

As stated before and shown in fig. 2 the sprat season 1919 had a very bad yield, and this obviously owing to a very weak stock. This condition gave occasion to the

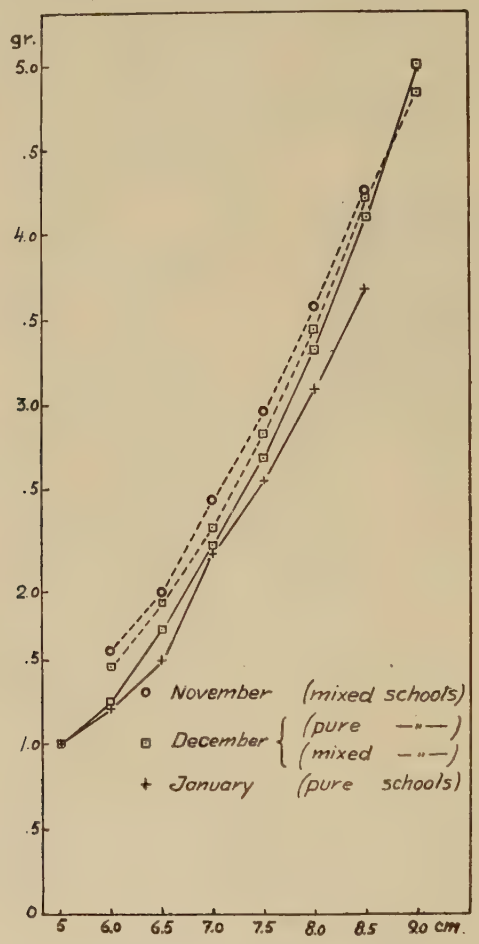


Fig. 5. Sprat, Youngfish. Length-weight relation, Nov. 1928—Jan. 1929. Ryfylke and Sunnhordland
——— from pure schools ------- from mixed schools.

recent sprat investigations, the industry and the fishermen asking for an inquiry into the matter, being afraid that the available stock had been exhausted by the previous fishing.

The year 1920 was an even year with middling good stock dispersed from the Naze to Statland, and some fishery all through the season. The yield was, however, to a

considerable extent diminished by a strike in the sardine industry from the middle of July to the first part of September.

The years 1921 and 1927 had good stocks and a very good sized sprat. The sprat stock was not very dispersed along the coast but in both years mostly localized in the southern parts. The fishery at each locality lasted, however, only a week or two, the sprat taking to deep water very early owing most probably to the larger size and the good development. In 1921 this change in the habitat of the sprat was accelerated by very wet weather. In 1921 a strike in the industry during June to a large extent diminished the yield. As shown in the figure the year 1927 has the heaviest yield of the years under consideration. This was partly due to a more brisk fishing activity at the east coast.

The year 1922 had a very weak fiord stock, especially in the southern fiords (Ryfylke). The fishery was, however, carried on in the central districts on quite a good spring immigration. As the dominating year-class 1921 seems to have been middling good the drift of the current during the summer and autumn 1921 must have been comparatively weak and the penetration into the fiords to some extent impaired.

The years 1923, 1924 and 1925 had very good fiord stocks. Especially during the last year the sprat was found in abundance dispersed along the coast and into the innermost fiords. A strike in the industry during high-summer and the discontinuation of the canning from the 17th October owing to the market situation diminished the yield to a considerable extent or the year would most probably have been the most lucrative as to the quantity of sprat caught in the years under consideration.

The year-classes 1922, 1923 and 1924 being respectively in dominance during the said three years seem to have had a very good autumn current to carry them northward along the coast. Young sprat of good quality occurred plentifully in mixed schools as far north as Sannessjöen at Helgeland (about the Polar circle) as early as in November during those years, and older sprats were found among the young herrings as far north as Harstad near Tromsö.

The contrary was the fate of the year-class 1925, which should have been in dominance during the fishing season 1926. A very good fishery of the year-class took place in the fiords of Ryfylke during some 3 weeks of June and as far north as the southern part of Sunnhordland some quantities of the year-class were found in early summer. Further north, however, from Hardangerfiord and northward, the older year-class 1924 was dominant, and the younger year-class was only found as an admixture. This is the only year during recent investigations that 2 year old sprat have been found dominant over a larger area and for a longer period. The yield of the fishery in those parts was, however, scanty and the same was the case in Ryfylke from the month of July, when the younger year-class seem to have been exhausted and older sprat were dominant. The June fishery in Ryfylke carried the sprat fishery of the west coast during that season.

In the southern part of the North Sea, at Ostend and Lowestoft etc. a very lucrative sprat fishery, the best known for years, took place during the autumn and winter of 1926. According to a lot of samples which I received from there, 80 per cent. of the sprat caught was of the year-class 1925. The year-class thus seems to have been very rich in some parts of the North Sea. Off the Norwegian west coast, however, it was

only found in quantities a little to the north of the Ryfylke fiords. The northward drift thus seems to have been too weak during the autumn of 1925 to carry any quantity of young sprat as far north along the west coast as in the preceding years. If there really exists a causal connection between the abundance of sprat of this year-class in the southern North Sea and its scanty occurance in the northern part of our West Norwegian sprat districts it is difficult to tell with our present knowledge of the sprat population of the North Sea. The conditions of the sprat stock off our west coast during 1926 is, however, interesting compared with that of other years with good dispersion of the sprat along the coast and especially of the year 1928, the year with the lowest yield for the west coast during the time statistics of our sprat fishery are available.

During 1928 the sprat stock off our coast seems to have been comparatively weak. The preceding autumn young sprat was observed in several places off the west coast and in some places it was observed during early spring as well. Some fishery took place in May and the first part of June in the innermost parts of Hardangerfiord, Sognefiord and Nordfiord, but later on there was very little fishery off our west coast. In Oslofiord and environs there was some fishery during early summer, and in September a good fishery, better than known for years, took place in Trondhjemsfiord. The conditions seem to indicate a weak stock scattered all along the coast to Trondhjemsfiord and penetrating even into the innermost fiords on the west coast.

Most likely the stock of young sprats off the west coast was not so weak as might be imagined from the yield in 1928. Contrary weather conditions, followed by hydrographical and biological changes in the waters of the fiords and sherries, impeded the rise of the sprats and forced the schools to take to deep water very early. This to some extent furthered the northward movement of the sprat schools during the summer, but that the primary northward drift of the young fish had been very strong and extensive also follows from the complete dispersion even into the innermost fiords from early spring.

This review of the West Norwegian sprat fishery from 1919 to 1928 may be summarized as follows:

The fishery during those years was affected by strikes (1920, 1921 and 1925) and the early cessation of the canning (1925) thus diminishing the yield.

Apart from this the following factors affecting the yield shown (fig. 2) may be discerned.

1) Hydrographical and biological situations (weather and food conditions etc.) during the fishing season affecting the runs and rises of the sprat.
2) Actual richness of the one year old year-class among the sprat population as a whole.
3) More or less favorable drift conditions from the spawning districts and along the Norwegian west coast, especially during the autumn preceding the fishing season under consideration.

The two latter conditions are the factors deciding the actual amount of the sprat stock and its dispersion in our West Norwegian sprat districts, and as shown the influence of both factors may be discerned from year to year, causing fluctuations in the stock and variations in the fishing situations.

Regarding the fate of the older year-classes only a few words may be added.

The two years old sprats leaving the fiords during spring and early summer, in their 3rd summer constitute a stock of older sprats inhabiting the waters in and out of the sherries (Skjergaarden). Sprats of that category have been found in coalfish and whales there, but are only fished for, when they push in between the sherries or penetrate into the fiords on the inside. Some years, however, a lot of sprats of this age get ripe and spawn in the outer fiords and afterwards leave the coast or go with the rest of the year-class. In the inner fiords, most years, only laggers and "land-locked" sprats of the year-class are left.

The bulk of the year-class inhabiting the outer coast waters seems to loiter there till the next spring, when 3 years old, the then mature sprats migrate south to the spawning districts proper, some years making themselves felt by striking the outer parts of the southern fiords (Ryfylke) during their migration, but leaving again very soon.

A young fish stock as pure and separate as the West Norwegian sprat stock, utilized by fishery to such an extent, is a very interesting occurrence and this is why I have tried to explain its conditions and changes at some length.

The fishery is as shown unstable and changable owing to the variations in the factors regulating the supply of immigrating young fish and to natural conditions prevaling during the fishery. It is, however, evident, that for a young fish stock as that sketched here, far removed from the principal spawning districts, the risk of overfishing is very unlikely and not to be feared.

If somewhat reliable forecasts could be made regarding a fishery of this hazardious kind it might be of great economical interest. The desiding hydrographical and biological factors are, however, too complex to allow of sure deductions in that line. Valuation of the amount of available stock some time before the fishing season is impeded by the fact that the time between the spawning and the utilization of the sprat by the fishery is too short to allow of a collection of sufficient material for such a valuation. Work in that line has, however, given some slight results, and especially regarding the comparative size of the year-classes from year to year and the advisability to commence the fishery early or late in the spring quite an amount of knowledge has been arrived at beforehand at least in those years, when the fishery has been continued into late autumn.

# XX. On the Fluctuations in Abundance exhibited by the Stock of Lake-herring *(Coregonus albula)* in Lake Keitele, Finland.

By

**T. H. Järvi.**

I may take it for granted that as a contribution to the numerous and illustrative instances of the surpassing and decisive influence of the fluctuations in the stock of fish on the yield of sea fisheries presented at this meeting of the International Council for the Exploration of the Sea, a parallel instance from the domain of inland lake fishery will be of interest to my audience. I therefore beg to present in the form of brief notes a series of observations on the fluctuations in the stock of the "lake-herring" *Coregonus albula* in Lake Keitele, Finland.

As a preliminary remark I may mention that from the economical point of view this species of fish is one of the most important fish stocks in the so-called lake district of Finland, especially in its great lakes. In its habits this species of Fish is comparable with the herring; it lives in open waters, being accordingly pelagic, it moves in shoals and feeds on plankton-crustacea. It could also be called "lake-herring" as we have done. Like its congener, the salmon, it, however, spawns in the autumn, viz. in October and November. The fertilized eggs sink to the bottom and remain there over the winter. Its spawning grounds are highly concentrated in certain places of the lake. A considerable portion of the fishing takes place at the spawning season on the spawning grounds; consequently there is no protection. Formerly it was fished exclusively with seines, but in recent times nets have also come into use.

I am going to present three tables. Table I indicates the number of the individuals in the samples taken by me for each year, and the distribution of the individuals between the different year-classes. The samples have always been taken from the catches at the spawning time from the same areas of water (Taimonniemi-area) and from several seine hauls. For this reason I regard my samples as highly representative even with respect to the stock. Table II presents the same statistics of year-classes as Table I, but rendered in per cents of the number of the individuals of the samples. I have not been able to collect statistics of the same type for the yield, but instead I shall present — Table III — relative estimates for the quantity of the yield in the different years

Table I. Representation of year classes in number of individuals in samples.

Age appears from difference between catch and spawning years.

| Year-classes | | Catch year and yield for same | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Spawning in autumn | Birth in spring | 1908 good | 1911 medium | 1912 poor | 1913 good | 1914 medium | 1915 poor | 1916 poor | 1917 crisis | 1918 crisis | 1919 good | 1920 medium | 1921 poor | 1922 crisis | 1923 medium | 1924 rather good | 1925 good | 1926 medium | 1927 medium | 1928 good |
| | | Number of individuals | | | | | | | | | | | | | | | | | | |
| **1904** | 1905 | 3 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| **1905** | 1906 | 135 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| **1906** | 1907 | **1137** | .. | .. | .. | .. | 1 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| **1907** | 1908 | 8 | 7 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| **1908** | 1909 | | 51 | 5 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| **1909** | 1910 | | **505** | **340** | 7 | .. | .. | 1 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| **1910** | 1911 | | .. | 1 | 43 | 4 | 1 | .. | 1 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| **1911** | 1912 | | | 4 | **490** | **391** | **199** | **29** | 3 | 1 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| **1912** | 1913 | | | | 2 | 28 | 58 | 20 | 4 | .. | 1 | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| **1913** | 1914 | | | | | .. | 64 | 11 | 13 | 1 | .. | 1 | .. | .. | .. | .. | .. | .. | .. | .. |
| **1914** | 1915 | | | | | | 2 | **180** | **161** | 25 | 2 | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| **1915** | 1916 | | | | | | | 4 | 5 | 1 | 7 | 1 | .. | .. | .. | .. | .. | .. | .. | .. |
| **1916** | 1917 | | | | | | | | .. | 16 | 18 | 11 | 1 | .. | .. | .. | .. | .. | .. | .. |
| **1917** | 1918 | | | | | | | | | .. | **379** | **377** | 76 | 6 | .. | .. | .. | .. | .. | .. |
| **1918** | 1919 | | | | | | | | | | .. | 12 | 82 | 48 | 5 | .. | .. | .. | .. | .. |
| **1919** | 1920 | | | | | | | | | | | .. | **262** | **151** | 11 | .. | .. | .. | .. | .. |
| **1920** | 1921 | | | | | | | | | | | | .. | 31 | 39 | .. | .. | .. | .. | .. |
| **1921** | 1922 | | | | | | | | | | | | | 14 | **1194** | 172 | 12 | .. | .. | .. |
| **1922** | 1923 | | | | | | | | | | | | | | 1 | **749** | 94 | 23 | 11 | .. |
| **1923** | 1924 | | | | | | | | | | | | | | | 14 | **1024** | **383** | **428** | 3 |
| **1924** | 1925 | | | | | | | | | | | | | | | | 20 | 42 | 45 | 21 |
| **1925** | 1926 | | | | | | | | | | | | | | | | | 2 | **147** | 16 |
| **1926** | 1927 | | | | | | | | | | | | | | | | | | 3 | **1090** |
| **1927** | 1928 | | | | | | | | | | | | | | | | | | | 11 |
| In all ... | | **1283** | **563** | **350** | **542** | **423** | **325** | **245** | **187** | **44** | **407** | **402** | **421** | **250** | **1250** | **935** | **1150** | **450** | **634** | **1141** |

and reliable statistics for the quantity of the roe derived from the fishing in the area of water under discussion at the spawning season (the roe is used as caviar and is collected separately). See also the graphical representation of the quantities of roe in Fig. 1.

An examination of these Tables brings out very clearly the following facts. The stock has always consisted of very few year-classes alone. We may state: It is maintained by the four lowest year-classes. Individuals older than that have been encountered only singly and in certain years. The oldest ones have been of seven years, and only one individual was interpreted as nine years old. The youngest, one-year class, is not affected by the fishery at the spawning season on the spawning grounds of the lake;

## Table II. Representation of year classes in samples in per cents.

Age appears from difference between catch and spawning years.

| Year-classes: Spawning in autumn | Year-classes: Birth in spring | Catch year and yield for same | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1908 | 1911 | 1912 | 1913 | 1914 | 1915 | 1916 | 1917 | 1918 | 1919 | 1920 | 1921 | 1922 | 1923 | 1924 | 1925 | 1926 | 1927 | 1928 |
| | | good | medium | poor | good | medium | poor | poor | crisis | crisis | good | medium | poor | crisis | medium | rather good | good | medium | medium | good |
| | | Number of individuals in per cents | | | | | | | | | | | | | | | | | | |
| **1904** | 1905 | 0.2 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| **1905** | 1906 | 10.6 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| **1906** | 1907 | **88.6** | .. | .. | .. | .. | 0.3 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| **1907** | 1908 | 0.6 | 1.2 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| **1908** | 1909 | | 9.1 | 1.4 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| **1909** | 1910 | | **89.7** | **97.2** | 1.3 | .. | .. | 0.4 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| **1910** | 1911 | | .. | 0.3 | 7.9 | 1.0 | 0.3 | .. | 0.5 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| **1911** | 1912 | | | 1.1 | **90.4** | **92.4** | **61.2** | **11.8** | 1.6 | 2.3 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| **1912** | 1913 | | | | 0.4 | 6.6 | 17.9 | 8.2 | 2.1 | .. | 0.2 | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| **1913** | 1914 | | | | | .. | 19.7 | 4.5 | 7.0 | 2.3 | .. | 0.3 | .. | .. | .. | .. | .. | .. | .. | .. |
| **1914** | 1915 | | | | | | 0.6 | **73.5** | **86.1** | **56.8** | 0.5 | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| **1915** | 1916 | | | | | | | 1.6 | 2.7 | 2.3 | 1.7 | 0.3 | .. | .. | .. | .. | .. | .. | .. | .. |
| **1916** | 1917 | | | | | | | | .. | 36.3 | 4.4 | 2.7 | 0.2 | .. | .. | .. | .. | .. | .. | .. |
| **1917** | 1918 | | | | | | | | | .. | **93.2** | **93.8** | 18.1 | 2.4 | .. | .. | .. | .. | .. | .. |
| **1918** | 1919 | | | | | | | | | | .. | 2.9 | 19.5 | 19.2 | 0.4 | .. | .. | .. | .. | .. |
| **1919** | 1920 | | | | | | | | | | | .. | **62.2** | **60.4** | 0.9 | .. | .. | .. | .. | .. |
| **1920** | 1921 | | | | | | | | | | | | .. | 12.4 | 3.1 | .. | .. | .. | .. | .. |
| **1921** | 1922 | | | | | | | | | | | | | 5.6 | **95.5** | 18.4 | 1.1 | .. | .. | .. |
| **1922** | 1923 | | | | | | | | | | | | | | 0.1 | **80.1** | 8.2 | 5.1 | 1.7 | .. |
| **1923** | 1924 | | | | | | | | | | | | | | | 1.5 | **89.0** | **85.1** | **67.5** | 0.3 |
| **1924** | 1925 | | | | | | | | | | | | | | | | 1.7 | 9.3 | 7.1 | 1.8 |
| **1925** | 1926 | | | | | | | | | | | | | | | | | 0.5 | 23.2 | 1.4 |
| **1926** | 1927 | | | | | | | | | | | | | | | | | | 0.5 | **95.5** |
| **1927** | 1928 | | | | | | | | | | | | | | | | | | | 1.0 |
| Quantity of roe collected | | | | | **184.0** | **55.0** | **12.1** | **16.3** | **4.5** | **7.5** | **112.0** | **67.0** | **16.8** | **2.0** | **36.5** | **77.5** | **102.0** | **68.5** | **47.0** | **95.4** |

they apparently have not shoaled to the spawning places. The bulk of the spawning stock has in all the years with good yield consisted of the two-year class. Such years were 1908, 1911, 1913, 1919, 1923, 1924, 1925 and 1928. The quantity of the yield in those years has decisively been determined by the two-year class: judging by the samples it has made up from 90 to 95 per cent. of the yield, 1924 only 80 per cent. In those years the year-classes older than two years have only figured as secondary sprinkle, representing 10 per cent. of the yield at most.

The two-year class has not occurred in the stock every year, nay, it has been absent even in two consecutive years or has been exceptionally weak. It goes without saying that under such conditions the quantity of the yield shows a catastrophic fall,

Table III. Statistics for quantity of roe collected and estimates for quantity of yield in different years.

| Catch year | Yield | Quantity of roe collected | Catch year | Yield | Quantity of roe collected | Catch year | Yield | Quantity of roe collected |
|---|---|---|---|---|---|---|---|---|
| | | kg. | | | kg. | | | kg. |
| 1907 | Excellent..... | **315.0** | 1914 | Medium..... | 55.0 | 1921 | Poor ..... | 16.8 |
| 1908 | Good..... | — | 1915 | Poor ..... | 12.1 | 1922 | Crisis..... | **2.0** |
| 1909 | Rather poor.. | — | 1916 | Poor ..... | 16.3 | 1923 | Medium..... | 36.5 |
| 1910 | Poor ..... | — | 1917 | Crisis..... | **4.5** | 1924 | Rather good | 77.5 |
| 1911 | Medium..... | — | 1918 | Crisis..... | **7.5** | 1925 | Good..... | **102.0** |
| 1912 | Poor ..... | — | 1919 | Good..... | **112.0** | 1926 | Medium..... | 68.5 |
| 1913 | Good..... | **184.0** | 1920 | Medium..... | 67.0 | 1927 | Medium..... | 47.0 |
| | | | | | | 1928 | Good..... | **95.4** |

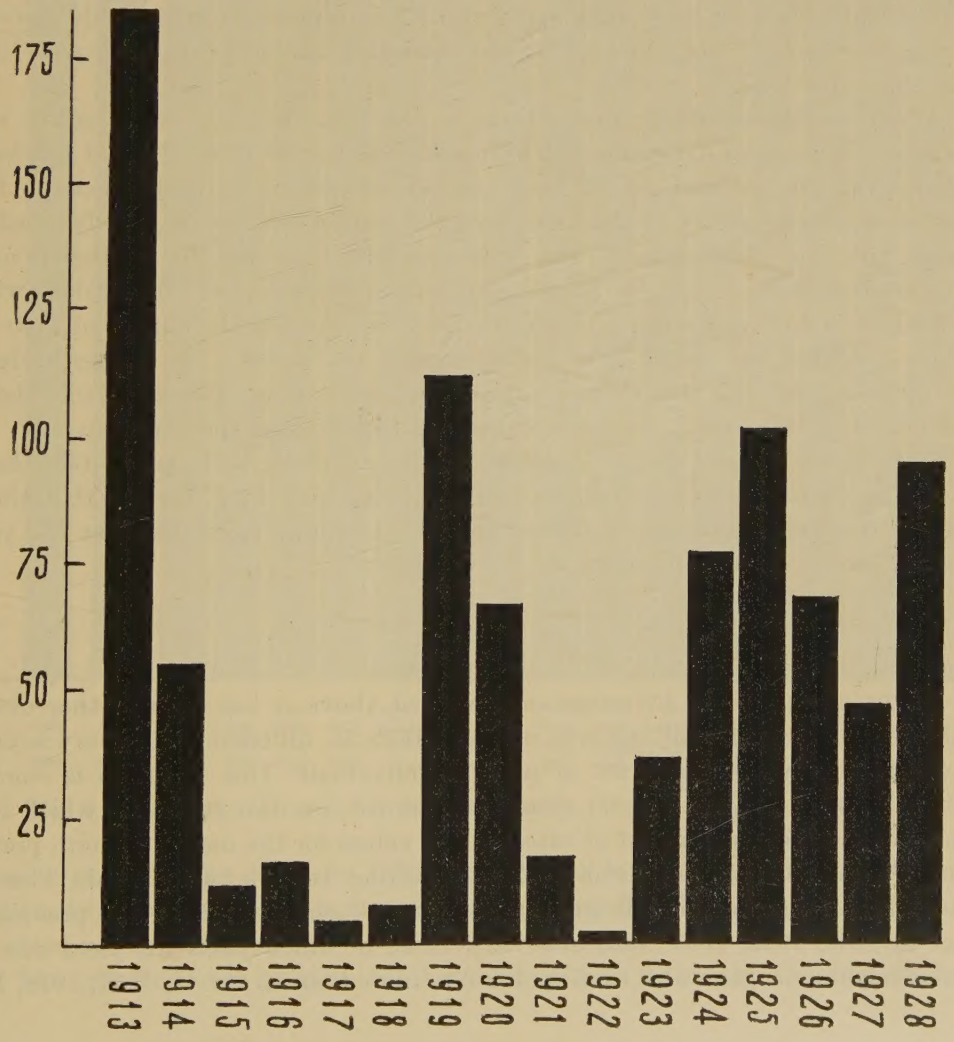


Fig. 1. The Quantity of roe derived from fishing at Taimonniemi-area in Keitale-lake from 1913 in kg.

although the individuals caught, being old, are big in size. During the absence of the two-year class the three-year class made up the bulk of the catch in 1912, 1914, 1917, 1922 and 1926, the four-year class, the two- as well as the three-year classes having been weak, in 1915, 1918 and 1927. For the reasons referred to it has been just the years 1915—1918 and 1922 that have been exceedingly critical in the fishery in the lake under discussion (cf. the sudden falls in the amount of the roe collected, indicated in Table III and in Fig. 1).

The violent fluctuations in the year-class composition of the stock and in the quantity of the yield are dependent on the wide variations in the year-classes. Year-classes with an abundance of individuals have been those derived from the spawning in the years 1906, 1909, 1911, 1914, 1917, 1921—1923 and 1926 and born in the following springs. These year-classes have made up the bulk of the catch of this species of fish yielded by this lake during the last twenty-one years (1908—1928). On the other hand, the year-classes derived from the spawning in the years 1910, 1912, 1913, 1915, 1916, 1918, 1920, 1924 and 1925 have been weak and with a small number of individuals. Successive weak year-classes have been yielded by the spawning in the years 1915 and 1916 as well as 1924 and 1925.

As to the causes of the fluctuations in the year-classes, I have earlier sought for them on the basis of data collected by me for the period 1908—1917. I reached the conclusions that the critical period for a year-class, the juncture at which its fate is decided, is the early spring, in the first place the time when the fry, newly freed from their eggs, rise from the bottom to the surface waters. Provided the weather is not too windy there is nothing to prevent the year-class from becoming rich in number; whereas if the weather is windy or stormy to a serious degree, there is the danger of their being destroyed (the wind and waves drive the fry against the shores). The danger of destruction is increased by the fact that the spawning grounds are concentrated. The data for the period 1918—1928 have not yet been worked out in the same manner.

It is highly typical of the stock of *Coregonus albula* in Lake Keitele that the number of the year-classes is exceedingly small, being only four; further that the fluctuations in the year-classes are wide and violent. It follows from this that the yield is capricious, subject to wide oscillations.

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In the course of the investigation reviewed above it has been further observed that the rate of growth and the size of individuals in different years vary according as they belong to year-classes rich or poor in individuals. This variation is elucidated by Table IV as far as the two-year class is concerned, i.e. the year-class which for the most part determines the amount of catches. The values for the medium length presented by Table IV are exhibited graphically in Fig. 2 making use of a natural scale. The values tabulated show: The medium length varies from 10 cm. (which length prevailed for instance in 1908, 1913, 1923, 1925 and 1928, in all of which years the yield was good; the lowest medium length was 9.7 cm. in 1925) to more than 13 cm. (in 1917, 1918, 1920—

1922, which years, with the exception of the mediocre year of 1920, were poor catch years). The widest variations are exhibited by the figures for weight, although, to my regret, I have not determined it for every year. The medium weight of male individuals

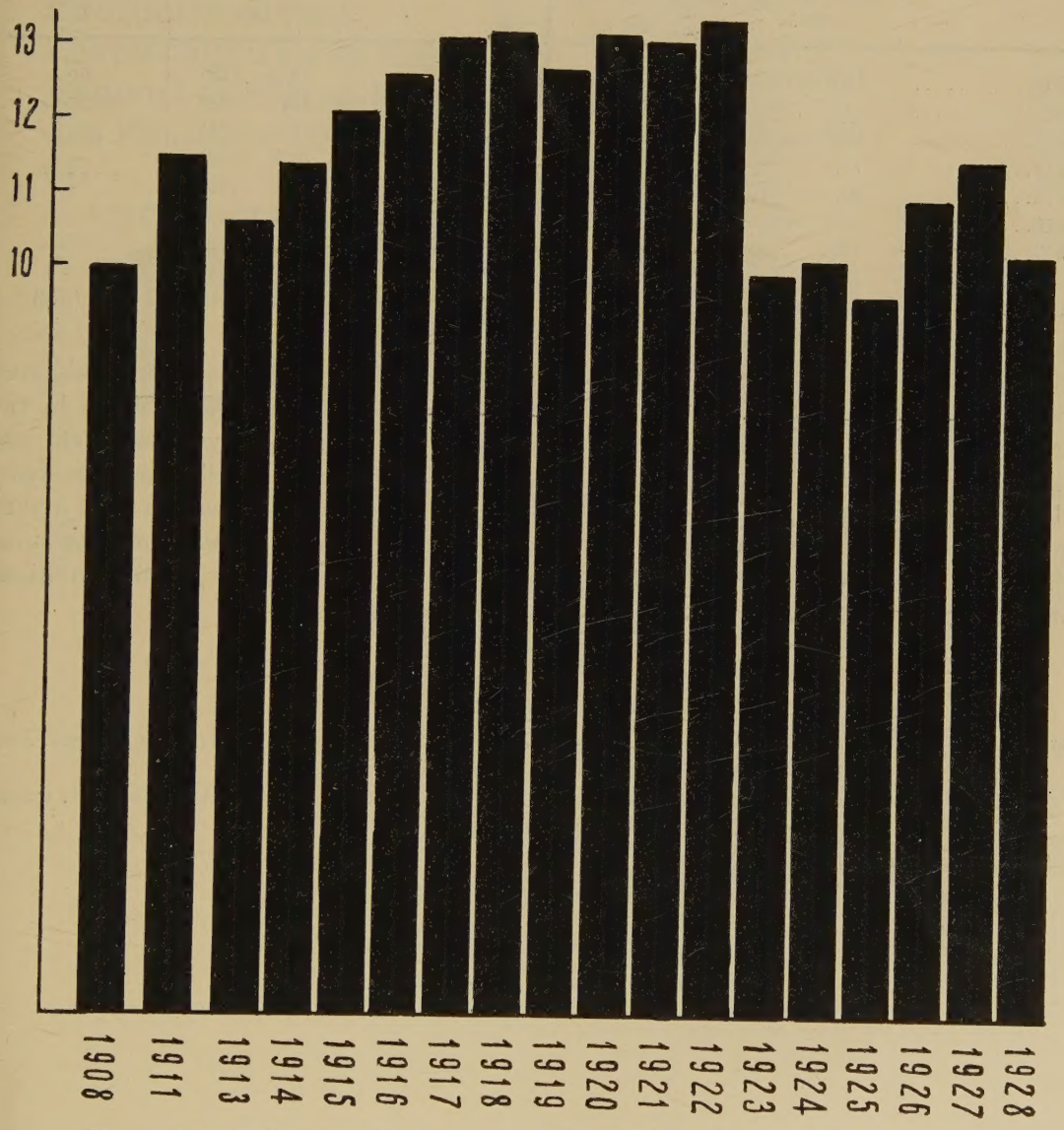


Fig. 2. Size (Medium-length) of two-year class in different years (in natural size).

has varied from 7.8 and 9.5 g. (in 1908 and 1928) as far as 16.4 g. (in 1916), nay, up to 19.9 g. (in 1917), although the last-mentioned figure is based on exceedingly few samples — no more were available.

The investigations carried out have brought to light also the fact that a new

Table IV. Medium size and weight of two-year class in 1908—1928.
(Figures in brackets indicate number of individuals measured and weighed).

| | Medium length cm. | Medium weight g. | | Medium length cm. | Medium weight g. |
|---|---|---|---|---|---|
| 1908..... | **10.0** (1137) | 7.8 (18) | 1920..... | 13.2 (12) | no |
| 1911..... | 11.5 (505) | 12.1 (393) | 1921..... | 13.1 (262) | weighings |
| 1913..... | **10.6** (490) | 10.0 (83) | 1922..... | 13.4 (31) | — |
| 1914..... | 11.4 (28) | 11.8 (18) | 1923..... | **10.0** (1194) | — |
| 1915..... | 12.1 (64) | 14.3 (29) | 1924..... | **10.2** (749) | — |
| 1916..... | 12.6 (180) | 16.4 (131) | 1925..... | **9.7** (1024) | — |
| 1917..... | 13.1 (5) | 19.9 (5) | 1926..... | 11.0 (42) | — |
| 1918..... | 13.2 (16) | no | 1927..... | 11.6 (147) | — |
| 1919..... | 12.7 (379) | weighings | 1928..... | **10.3** (1090) | 9.5 (646) |

year-class with an abundance of individuals may arise suddenly and from a very decimated stock. Thus for instance the two-year class with an abundance of individuals in the catch of 1919 had sprung up from the spawning for 1917, in which year the yield was exceedingly small and the stock was indisputably in a critical state. Similarly the year-class derived from the spawning for 1922, yielded at the age of two years in 1924 a very good catch, although the respective stock had been extremely weak. These instances show that the reinforcement of the stock may take place also suddenly, if the conditions at the critical moments of the regeneration period are favourable.

## References.

JÄRVI, T. H., 1920. Die kleine Maräne, *Coregonus albula* L., in Keitelesee. Annales Acad. scient. Fennicae. Ser. A. Vol. 14. Also swedish in Finlands Fiskerier. 5.

— 1924. Die kleine Maräne, *Coregonus albula* L., im Nilakka und Pielavesi. Annales Acad. scient. Fennicae. Ser. A. Vol. 21. Also in Finlands Fiskerier. 7.